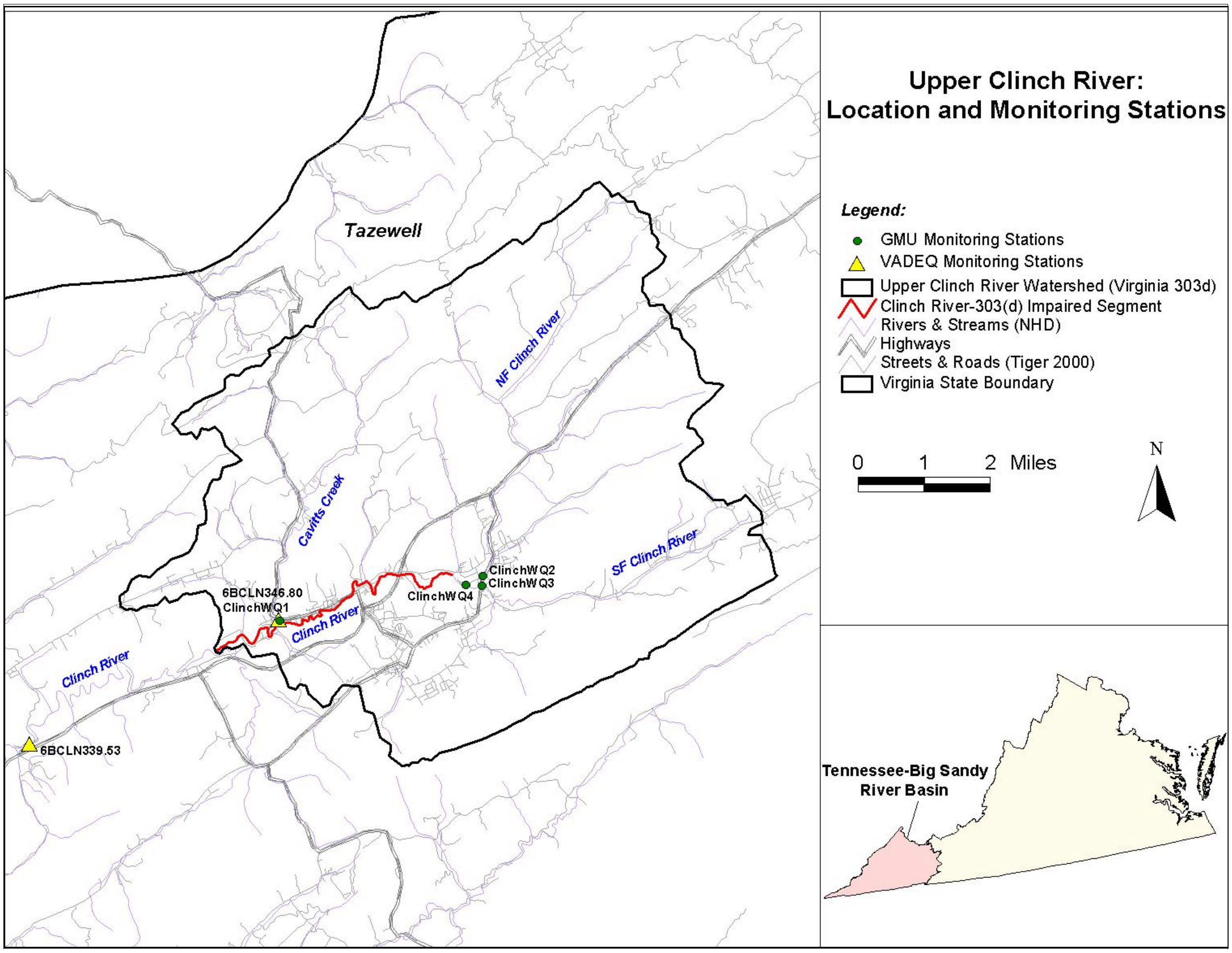
Total Maximum Daily Load (TMDL) Development for the Upper Clinch River Watershed

Aquatic Life Use (Benthic) Impairment



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Background

The Upper Clinch River watershed is located in Tazewell County, Virginia, in the Tennessee/Big Sandy River Basin (USGS Hydrologic Unit Code, 06010205) (Figure 1.1). The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAS-P01R.

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 1997). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the EPA's Rapid Bioassessment Protocol (RBP) ranking is either moderately or severely impaired. As a result, the Upper Clinch River was listed as impaired due to violations of the general standard (aquatic life).

Water quality data analyses and field observations indicate that the primary cause of the benthic community impairment in the Upper Clinch River is increased amounts of sediment. In order to improve water quality conditions that have resulted in benthic community impairments, a Total Maximum Daily Load (TMDL) was developed for the impaired stream, taking into account all sources of sediment in the watershed, plus a margin of safety (MOS).

Upon implementation, the TMDL will ensure that water quality conditions relating to benthic impairment will meet the allowable loadings estimated by use of a reference watershed (a non-impaired watershed with characteristics similar to those of the impaired watersheds).

Sources of Sediment

Sediment sources can be divided into point and non point sources. There are currently five permitted facilities in the Upper Clinch River watershed (Table 1).

Table 1. VPDES permitted facilities in the Upper Clinch River watershed

Stream	Facility Name	VPDES Permit No.	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L)	TSS Load (metric tons/year)
Mundy Branch, UT	Glenrae II Mobile Home Park STP	VA0065676	Municipal	0.4850	60	0.4021
Clinch River	Tazewell WWTP	VA0026298	Municipal	2.0000	30	82.9005
Clinch River	Greater Tazewell Area Reg WTP	VA0053465	Municipal	0.0250 (total flow)	60	2.6200
Clinch River, UT	Tazewell County Landfill*	VAR051267	Stormwater	0.4639	100**	7.7427
Mundy Branch, UT	Bannies Wash Bays	VAG750017	General	0.0010	30	0.0634

*Permitted load for this facility was calculated as the average annual modeled runoff times the area governed by the permit times a maximum TSS concentration of 100 mg/L. Flow was based on the average annual runoff from urban lands.
**No limit was specified in the permit; threshold value was used.

Sediment loads are primarily contributed by nonpoint sources in the Upper Clinch River watershed. The major source of sediment is agricultural land. Agricultural lands can contribute excessive sediment loads through erosion and build-up/washoff processes. Agricultural lands are particularly susceptible to erosion due to less vegetative coverage. Streambank erosion has also been noted as a potential source of sediment in these watersheds.

Modeling

TMDLs were developed using BasinSim 1.0 and the GWLF model. GWLF is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment, based on daily water balance totals that are summed to give monthly values.

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. The USGS streamflow gage (003524000), located on Clinch River at Cleveland, VA, was used to calibrate hydrology for the impaired watershed (Upper Clinch River) and USGS streamflow gage 03173000, located on Walker Creek at Bane, VA, was used to calibrate hydrology for the reference watershed. Flow data were available from these gages for the calibration periods: April 1, 1991 - September 30, 2002 (impaired) and April 1, 1981 through May 31, 1999 (reference). The calibration period covered a range of hydrologic conditions, including low- and high-flow conditions as well as seasonal variations. The calibrated GWLF model adequately simulated the hydrology of the impaired watershed.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for nutrients (i.e., total phosphorus and total nitrogen), sediment, and other parameters that may be contributing to the impaired condition of the benthic community in these streams. Therefore, a reference watershed approach was used to determine the primary benthic community stressors and to establish numeric endpoints for these stressors. This approach is based on selecting a non-impaired watershed that shares similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses. Walker Creek was chosen as the reference watershed and any reductions of sediment from the impaired waterbody were based on the reference load of sediment in the Walker Creek watershed.

Existing Conditions

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. To establish baseline (reference watershed) loadings for sediment the GWLF model for Walker Creek was used. For TMDL calculation, both the calibrated reference and calibrated impaired watersheds were modeled for an eight-year period from 4/1/1991 to 3/31/1999. This was done to standardize the modeling period. In addition, the total area for the reference watershed was reduced to be equal to its paired target watershed. This was necessary because watershed size influences sediment delivery to the stream and other model variables.

The annual average loads for pollutants of concern were determined for each land use/source category in the reference and the impaired watershed. This modeling period was used, after calibration, to represent a broad range of recent weather and hydrologic conditions.

Margin of Safety

While developing allocation scenarios for the TMDL, an explicit margin of safety (MOS) of ten percent was used. Ten percent of the reference sediment load was calculated and added to the sum of the load allocation (LA) and waste load allocation (WLA) to produce the TMDL. It is assumed that a MOS of 10% will account for any uncertainty in the data and the computational methodology used for the analysis, as well as provide an additional level of protection for designated uses.

Allocation Scenarios

Load or waste load allocations were assigned to each source category in the watersheds. Several allocation scenarios were developed for the Upper Clinch River watershed to examine the outcome of various load reduction combinations. The recommended scenario for the Upper Clinch River (Table 2) is based on maintaining the existing percent load contribution from each source category. Two additional scenarios are presented for comparison purposes (Table 3). Load reductions from agricultural sources are minimized in the first alternative and reductions from urban lands are minimized in the second alternative. The recommended scenario balances the reductions from agricultural and urban sources by maintaining existing watershed loading characteristics. In each scenario, loadings from certain source categories were allocated according to their existing loads. For instance, sediment loads from forest lands represent the natural condition that would be expected to exist; therefore, the loading from forest lands was not reduced. Also, sediment loads from point sources were not reduced because these facilities are currently meeting their pollutant discharge limits and other permit requirements and because these loads were insignificant as compared with other sources. Current permit requirements are expected to result in attainment of the WLAs as required by the TMDL. Point source contributions, even in terms of maximum flow, are minimal, therefore, no reasonable potential exists for these facilities to have a negative impact on water quality and there is no reason to modify the existing permits. Note that the sediment WLA values presented in the following tables represent the sum of all point source WLAs, minus in-stream transport loss.

Table 2. Recommended sediment allocations for Upper Clinch River

Source Category	Sediment Load Allocation (lbs/yr)	Sediment % Reduction
Forest	223,395	0%
Water	0	0%
Pasture/Hay	5,134,583	56%
Cropland	978,662	55%
Barren/Transitional/Quarries	60,385	55%
Urban (includes pervious & impervious)	217,590	55%
Groundwater	0	0%
Point Sources (WLA)	Total = 206,636 *Glenrae Mobile Home = 886* *Tazewell WWTP = 182,764* *Greater Tazewell Area Reg WTP = 5,776* *Tazewell County Landfill = 17,070* *Bannies Wash Bays = 140*	0%
TMDL Load (minus MOS)	6,821,251	54%

Table 3. Alternative sediment allocations for Upper Clinch River

Source Category	Minimize Agricultural Reductions	Minimize Urban Reductions
Forest	0.0%	0.0%
Water	0.0%	0.0%
Pasture/Hay	54.0%	59.0%
Cropland	54.0%	54.0%
Barren/Transitional/Quarries	90.0%	0.0%
Urban (includes pervious & impervious)	95.0%	0.0%
Groundwater	0.0%	0.0%
Point Sources (WLA)	0.0%	0.0%

The TMDLs established for these streams consist of a point source waste load allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDLs were based on the total load calculated for the Walker Creek watershed (area adjusted to the appropriate watershed size).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis.

TMDLs were calculated by adding reference watershed loads for sediment together with point source loads to give the TMDL value (Table 4).

Table 4. TMDL for Upper Clinch River

TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall % Reduction
7,580,309	6,614,615	Total = 206,636 *Glenrae Mobile Home = 886* *Tazewell WWTP = 182,764* *Greater Tazewell Area Reg WTP = 5,776* *Tazewell County Landfill = 17,070* *Bannies Wash Bays = 140*	759,058	54.2%

SECTION 1

INTRODUCTION

1.1 Background

1.1.1 TMDL Definition and Regulatory Information

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (USEPA 1991).

1.1.2 Impairment Listing

The Upper Clinch River is listed as impaired on Virginia's Section 303(d) Total Maximum Daily Load Priority List and Report for violations of the General Standard (Benthics) (VADEQ 1998 & 2002b). The Upper Clinch River was placed on Virginia's Section 303(d) list in 1998 for partial support of the Aquatic Life Use due to the results of biological monitoring efforts conducted by VADEQ at biomonitoring station 6BCLN346.80 in May 1995 and June 1997. The biologist involved in the 1997 effort noted that the habitat was impacted due to heavy siltation. The impaired segment is 5.5 miles in length and extends from the Upper Clinch River confluence with Lincolnshire Branch downstream to its confluence with Plum Creek.

1.1.3 Watershed Location

The Upper Clinch River watershed is located in Tazewell County, Virginia, in the Tennessee/Big Sandy River Basin (USGS Hydrologic Unit Code, 06010205) (Figure 1.1). The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAS-P01R.

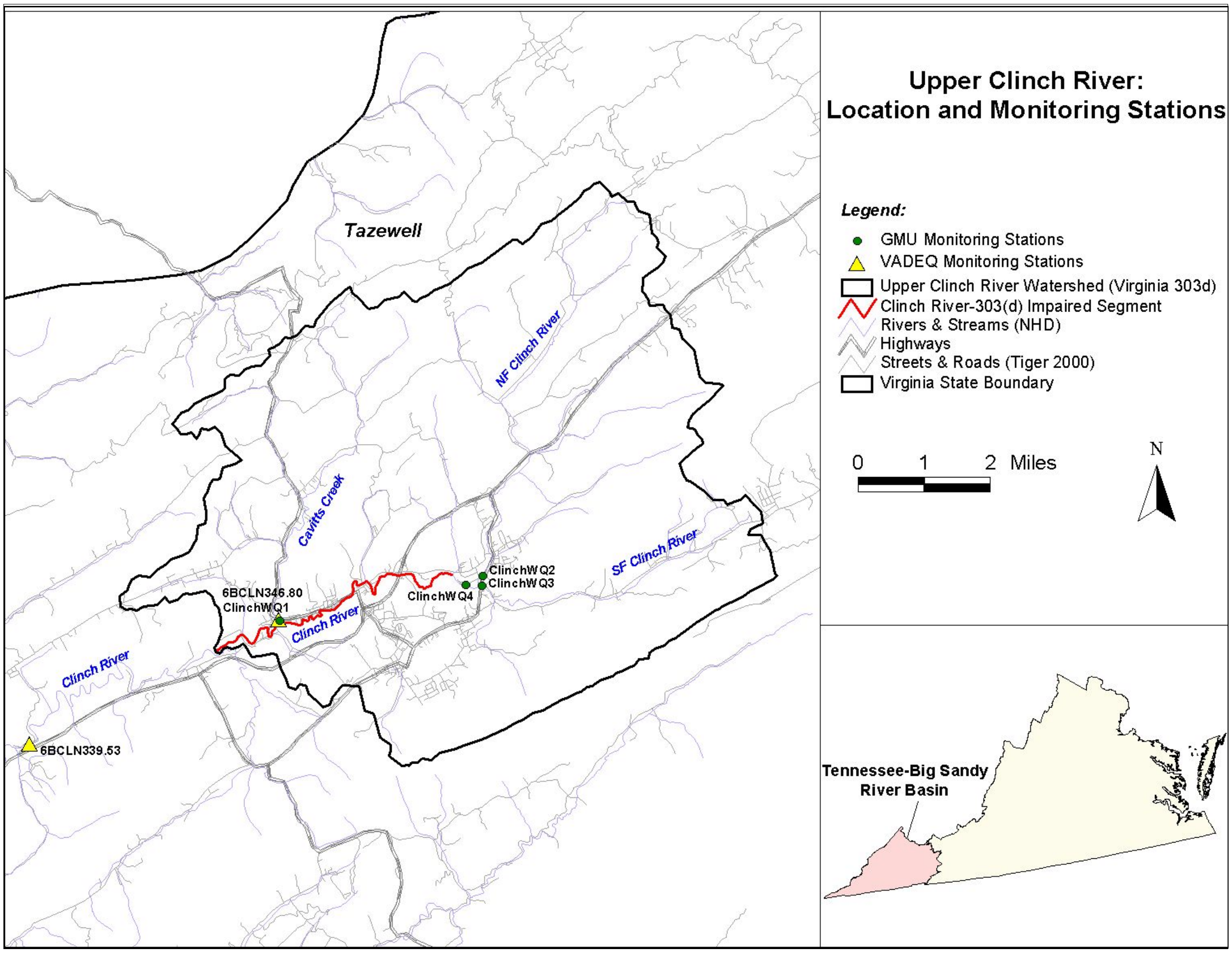

Figure 1.1 Location of impaired watershed

1.2 Designated Uses and Applicable Water Quality Standards

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "Water quality standards" *means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§ 62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC § 1251 et seq.).*

1.2.1 Designation of Uses (9 VAC 25-260-10)

A. All state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of *edible and marketable natural resources (e.g., fish and shellfish).*

The Upper Clinch River does not support the aquatic life designated use due to violations of the general (benthic) criteria (see Section 1.2.2).

1.2.2 Water Quality Standards

General Criteria (9 VAC 25-260-20)
A. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.

Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled.

1.3 Biomonitoring and Assessment

Direct investigations of biological communities using rapid bioassessment protocols, or other biosurvey techniques, are best used for detecting aquatic life impairments and assessing their relative severity (Plafkin et al. 1989). Biological communities reflect overall ecological integrity; therefore, biosurvey results directly assess the status of a waterbody relative to the primary goal of the Clean Water Act. Biological communities integrate the effects of different pollutant stressors and thus provide a holistic measure of their aggregate impact. Communities also integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions.

Many state water quality agencies use benthic macroinvertebrate community data to assess the biological condition of a waterbody. Virginia uses EPA's Rapid Bioassessment Protocol (RBP II) to determine the status of a stream's benthic macroinvertebrate community. This procedure relies on comparisons of the benthic macroinvertebrate community between a monitoring station and its designated reference site. Measurements of the benthic community, called metrics, are used to identify differences between monitored and reference stations. Metrics used in the RBP II protocol include taxa richness, percent contribution of dominant family, and other measurements that provide information on the abundance of pollution tolerant versus pollution intolerant organisms. Biomonitoring stations are typically sampled in the spring and fall of each year. The biological condition scoring criteria and the bioassessment matrix are discussed in the technical document, *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (Plafkin et al. 1989). The RBPII bioassessment scoring matrix is presented in Table 1.1.

Table 1.1 Bioassessment scoring matrix (Plafkin et al. 1989)

% Compare to Reference Score (a)	Biological Condition Category	Attributes
>83%	Non-Impaired	Optimum community structure (composition and dominance).
54 - 79%	Slightly Impaired	Lower species richness due to loss of some intolerant forms.
21 - 50%	Moderately Impaired	Fewer species due to loss of most intolerant forms.
<17%	Severely Impaired	Few species present. Dominant by one or two taxa. Only tolerant organisms present.
(a) Percentage values obtained that are intermediate to the above ranges require subjective judgement as to the correct placement.		

Virginia 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue and sediments; and biological evaluation of benthic community data (VADEQ 1997). Benthic community assessments are, therefore, used to determine compliance with the General Criteria section of Virginia's Water Quality Standards (9 VAC 25-260-20). In general, the stream reach that a biomonitoring station represents is classified as impaired if the RBP ranking is either moderately or severely impaired. As a result, the Upper Clinch River was listed as impaired due to violations of the general standard (aquatic life).

SECTION 2

BENTHIC TMDL ENDPOINT DETERMINATION

2.1 Reference Watershed Approach

Biological communities respond to any number of environmental stressors, including physical impacts and changes in water and sediment chemistry. According to Virginia's 2002 303(d) list, the probable cause of benthic impairment was attributed to siltation from urban and agricultural non-point sources.

TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. Numeric endpoints represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. Virginia does not currently have numeric criteria for nutrients (i.e., total phosphorus and total nitrogen), sediment, and other parameters that may be contributing to the impaired condition of the benthic community in this stream. A reference watershed approach was, therefore, used to determine the primary benthic community stressors and to establish numeric endpoints for these stressors. This approach is based on selecting non-impaired watersheds that share similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses. The Virginia Stream Condition Index (VaSCI) was used to define differences in the benthic communities in impaired and reference streams (USEPA, 2003). Loading rates for pollutants of concern are determined for impaired and reference watersheds through modeling studies. Both point and nonpoint sources are considered in the analysis of pollutant sources and in watershed modeling. Numeric endpoints are based on reference watershed loadings for pollutants of concern and load reductions necessary to meet these endpoints are determined. TMDL load allocation scenarios are then developed based on an analysis of the degree to which contributing sources can be reasonably reduced.

2.2 Watershed Characterization

2.2.1 General Information

The Upper Clinch River watershed is located in Tazewell County, Virginia, in the Tennessee/Big Sandy River Basin (USGS Hydrologic Unit Code, 06010205) (Figure 1.1). The watershed is located in the middle of Tazewell County, approximately 2 miles south of the Virginia/West Virginia state line. The waterbody identification code (WBID, Virginia Hydrologic Unit) is VAS-P01R. The impaired stream length is approximately 5.5 miles and extends from the Upper Clinch River confluence with Lincolnshire Branch downstream to its confluence with Plum Creek. The Upper Clinch River watershed is approximately 30,611 acres.

2.2.2 Geology

The Upper Clinch River is located in the transitional Appalachian Plateau to Valley and Ridge physiographic province.

The Valley and Ridge physiographic province is characterized by elongate parallel ridges and valleys that are underlain by folded Paleozoic sedimentary rock. This topography is the result of the continuous differential weathering of linear belts of rocks that have been repeatedly exposed and covered by folding and faulting. Cambrian clastic sediments of the western Blue Ridge are overlain by carbonates that made up the Great American Bank. Today these carbonates (up to 3.5 km in thickness) are exposed in the Great Valley. Well-developed karst topography is characteristic of the Great Valley and many caverns are located on the subsurface.

The Appalachian Plateau lies to the northwest of the Valley and Ridge province. The boundary between the two provinces is a transition from the tight folds of the Valley and Ridge to low-amplitude folds and flat-lying rocks in the Plateau. Although some parts of the Plateau exhibit a low relief plateau-like morphology, much of the Appalachian Plateau is strongly dissected by stream erosion and the topography is rugged. Regional scale folds in the Plateau formed in response to shortening on thrust faults that do not reach the surface and are rooted to the east in the Valley and ridge province. The upper Paleozoic strata of the Plateau are rich in mineral resources such as coal, natural gas, and petroleum.

2.2.3 Soils

Soils data were obtained from the State Soil Geographic (STATSGO) database which includes general soils data and map unit delineations for the United States. GIS coverages provide accurate locations for the soil map units (MUIDs) at a scale of 1:250,000 (NRCS, 1994). A map unit is composed of several soil series having similar properties. STATSGO map units that cover a portion of the Upper Clinch River watershed are shown in Figure 2.1. The predominant map unit in this watershed is VA003. Also present are STATSGO map units VA001, VA005, VA047, and VA076. The following soil description is based on NRCS Official Soil Descriptions (1998-2002).

STATSGO map unit - VA003 is composed of the following soil series, in order of dominance: Frederick, Carbo, Timberville, Poynor, Chilhowie, Laidig, and Sindion. The Frederick series accounts for 66% of the map unit. The Frederick series consists of very deep, well-drained soils formed in residuum derived mainly from dolomitic limestone with interbeds of sandstone, siltstone, and shale. They are located on nearly level to very steep uplands. Permeability is moderate. Slopes range from 0 to 60%. Hydrologic soil group - B.

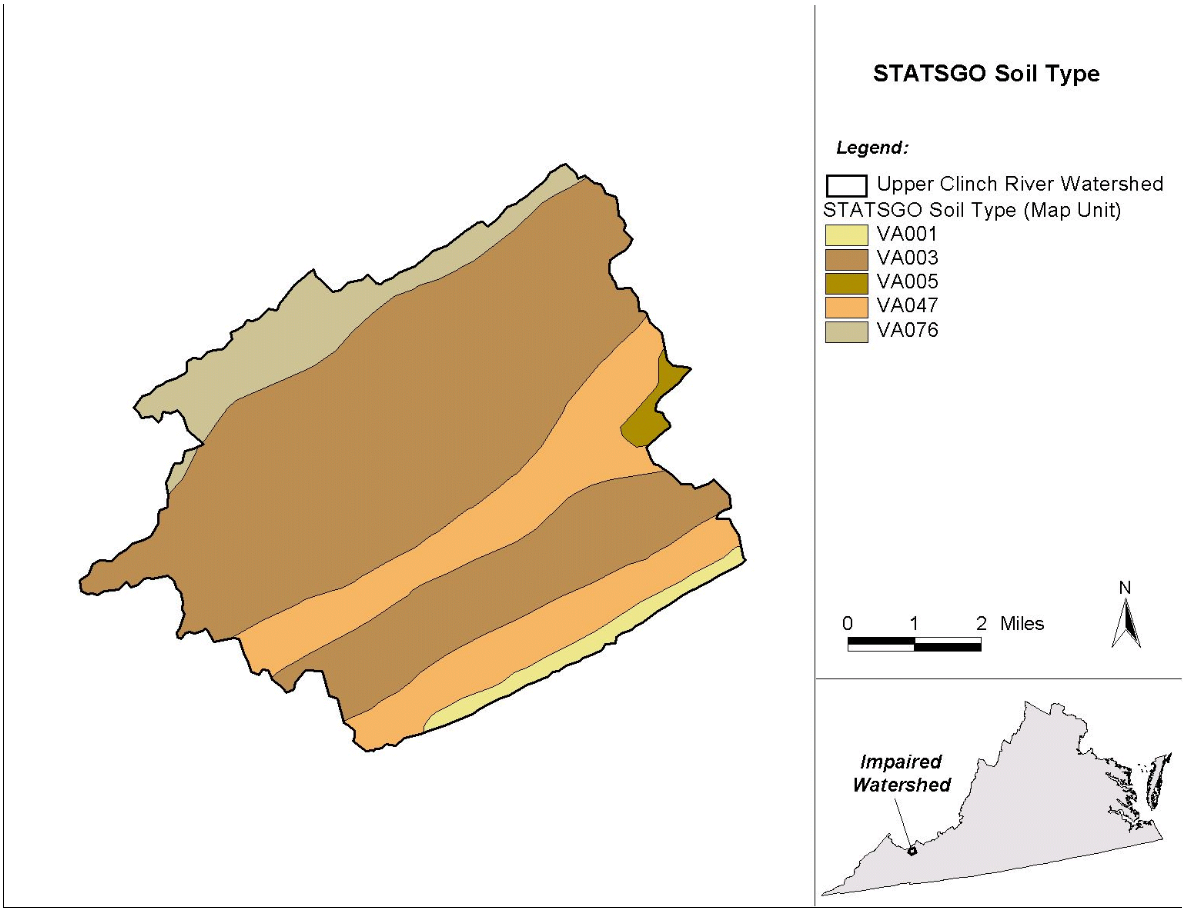

Figure 2.1 STATSGO soil types for the Upper Clinch River watershed

2.2.4 Climate

The area's climate is typical of other transitional Appalachian Plateau to Valley and Ridge areas in Virginia. Weather data for this watershed can be characterized using the Grundy meteorological station (NCDC), which is located approximately 29 miles west-northwest of the watershed (period of record: 1948-2003). The growing season lasts from April 20 through October 24 in a typical year (SERCC 2003). Average annual precipitation is 44.25 inches with July having the highest average precipitation (4.92 inches). Average annual snowfall is 17.5 inches, most of which occurs in January and February. The average annual maximum and minimum daily temperature is 68.5ºF and 42.7ºF, respectively. The highest monthly temperatures are recorded in August (86.4ºF - avg. maximum) and the lowest temperatures are recorded in January (22.3ºF - avg. minimum).

2.2.5 Land Use

General land use/land cover data for the Upper Clinch River watershed was extracted from the Multi-Resolution Land Characterization (MRLC) database for the state of Virginia (MRLC, 1992) and is shown in Figure 2.2. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data available. Land uses in the watershed include various urban, agricultural, and forest categories (Table 2.1 and Figure 2.2). Over 50% of the watershed is forested, while approximately 45% of the watershed is used for agricultural purposes. Urban lands account for only about 4% of the watershed. Individual land use types were consolidated into six broader categories that had similar erosion/pollutant transport attributes for modeling.

Table 2.1 MRLC and consolidated land uses in the Upper Clinch River watershed

MRLC Land Use	Area (acres)	Percent	Consolidated Land Use	Area (acres)	Percent
Woody Wetlands	15.8	0.05%	Forest	15,857.7	51.80%
Emergent Herbaceous Wetlands	16.6	0.05%			
Deciduous Forest	12,626.5	41.25%			
Evergreen Forest	589.1	1.92%			
Mixed Forest	2,609.7	8.53%			
Open Water	74.6	0.24%	Water	74.6	0.24%
Pasture/Hay	12,538.8	40.96%	Pasture/Hay	12,538.8	40.96%
Row Crops	992.9	3.24%	Cropland	992.9	3.24%
Transitional	38.3	0.13%	Transitional	38.3	0.13%
High Intensity Residential	2.2	0.01%	Urban (pervious & impervious)	1,108.3	3.62%
High Intensity Commercial/ Industrial/ Transportation	166.1	0.54%			
Low Intensity Residential	695.1	2.27%			
High Intensity Residential - impervious	1.5	0.00%			
Low Intensity Residential - impervious	77.3	0.25%			
High Intensity Commercial/ Industrial/ Transportation - impervious	166.1	0.54%			
Total	30,611	100%	Total	30,611	100%

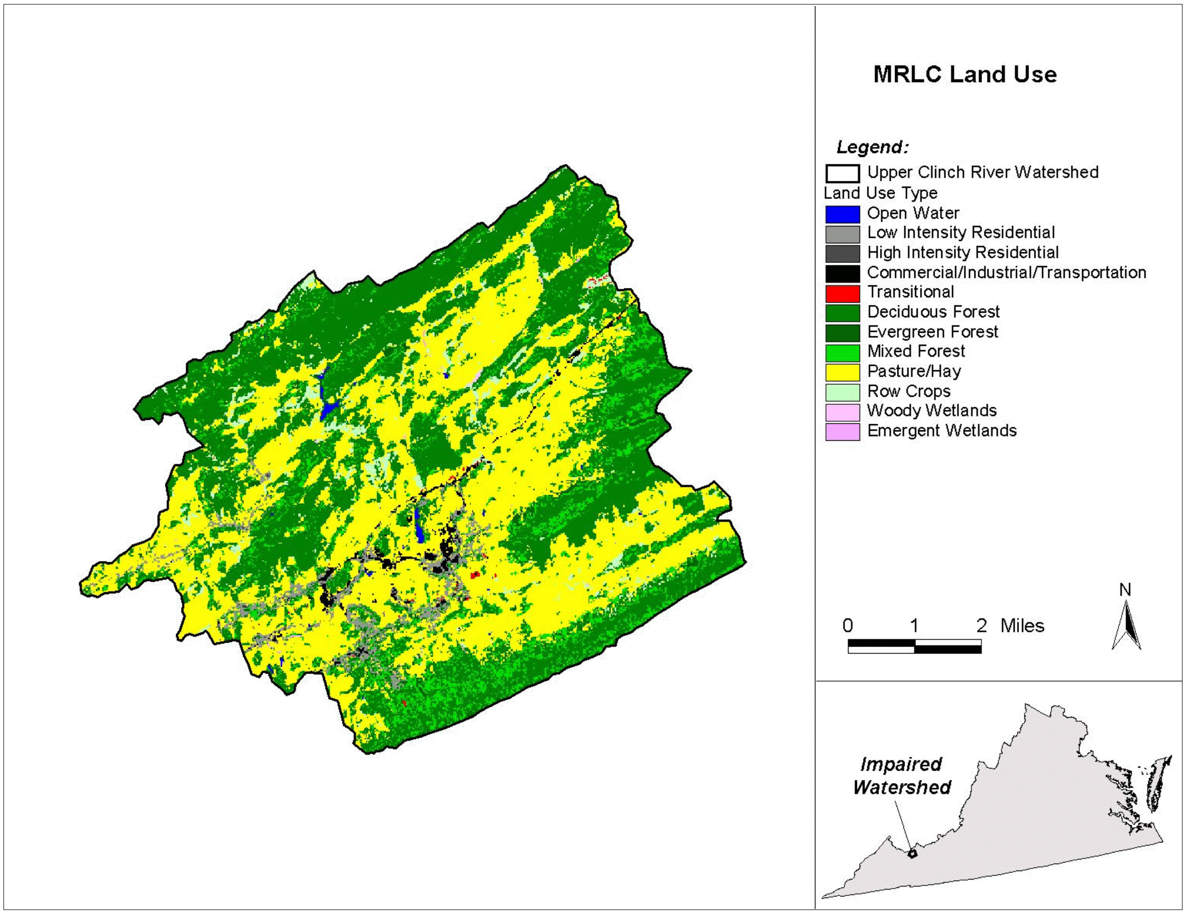

Figure 2.2 MRLC land use in the Upper Clinch River watershed

2.2.6 Ecoregion

The Upper Clinch River watershed is located in the transitional Central Appalachians to Central Appalachian Ridges and Valleys ecoregion - Level III classifications 69 and 67 respectively (Woods et al. 1999).

The Central Appalachian ecoregion, stretching from central Pennsylvania to northern Tennessee, is primarily a high, dissected, rugged plateau composed of sandstone, shale, conglomerate, and coal. The rugged terrain, cool climate, and infertile soils limit agriculture, resulting in a mostly forested land cover. The high hills and low mountains are covered by a mixed mesophytic forest with areas of Appalachian oak and northern hardwood forest.

The Central Appalachian Ridges and Valley is a northeast-southwest trending, relatively low-lying, but diverse ecoregion, sandwiched between generally higher, more rugged mountainous regions with greater forest cover. As a result of extreme folding and faulting events, the region's roughly parallel ridges and valleys have a variety of widths, heights, and geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Springs and caves are relatively numerous. Present-day forests cover about 50% of the region. The ecoregion has a diversity of aquatic habitats and species of fish.

At a finer scale, the Upper Clinch River watershed is located in the Southern Limestone/Dolomite Valleys, the Southern Sandstone Ridges and the Cumberland Mountains subecoregions - Level IV classifications 67f, 67h, and 69d respectively (Woods et al. 1999) (Figure 2.3).

The Southern Limestone/Dolomite Valleys subecoregion is a lowland characterized by broad, undulating, fertile valleys that are extensively farmed. Sinkholes, underground streams, and other karst features have developed on the underlying limestone/dolomite, and as a result, the drainage density is low. Where streams occur they tend to have gentle gradients, plentiful year round flow, and distinctive fish assemblages. Ordovician and Cambrian limestone and dolomite commonly underlie the region. Interbedded with the carbonates are other rocks, including shale. Crestal elevations vary from 1,640 to 3,200 feet.

The Southern Sandstone Ridges subecoregion is composed of high, steep, forested ridges with narrow crests. The ridge-forming strata are composed of folded, interbedded Paleozoic sandstone and conglomerate. Other less resistant rocks, such as shale and siltstone, form the side slopes. Today, extensive forest covers the region. Crestal elevations range from about 2,300 feet to 3,450 feet and local relief ranges from approximately 500 to 1,500 feet.

The Dissected Appalachian Plateau, or Cumberland Mountains, subecoregion is a strongly dissected region with steep slopes, very narrow ridgetops, and extensive forests. It is primarily underlain by flat-lying Pennsylvania sandstone, shale, and coal of the Pottsville Group. Typically crests range in elevation from 1,200 feet to about 3,699 feet and are from 350 to 550 feet above narrow valleys. Well-drained soils of low fertility have developed on the sedimentary rocks, which originally supported mixed Mesophytic Forest (Kuchler, 1964). Today, commercial woodland is common in the region and approximately 90% of the rugged ecoregion is forested. In wider valleys, scattered towns and small-scale livestock farms are found.

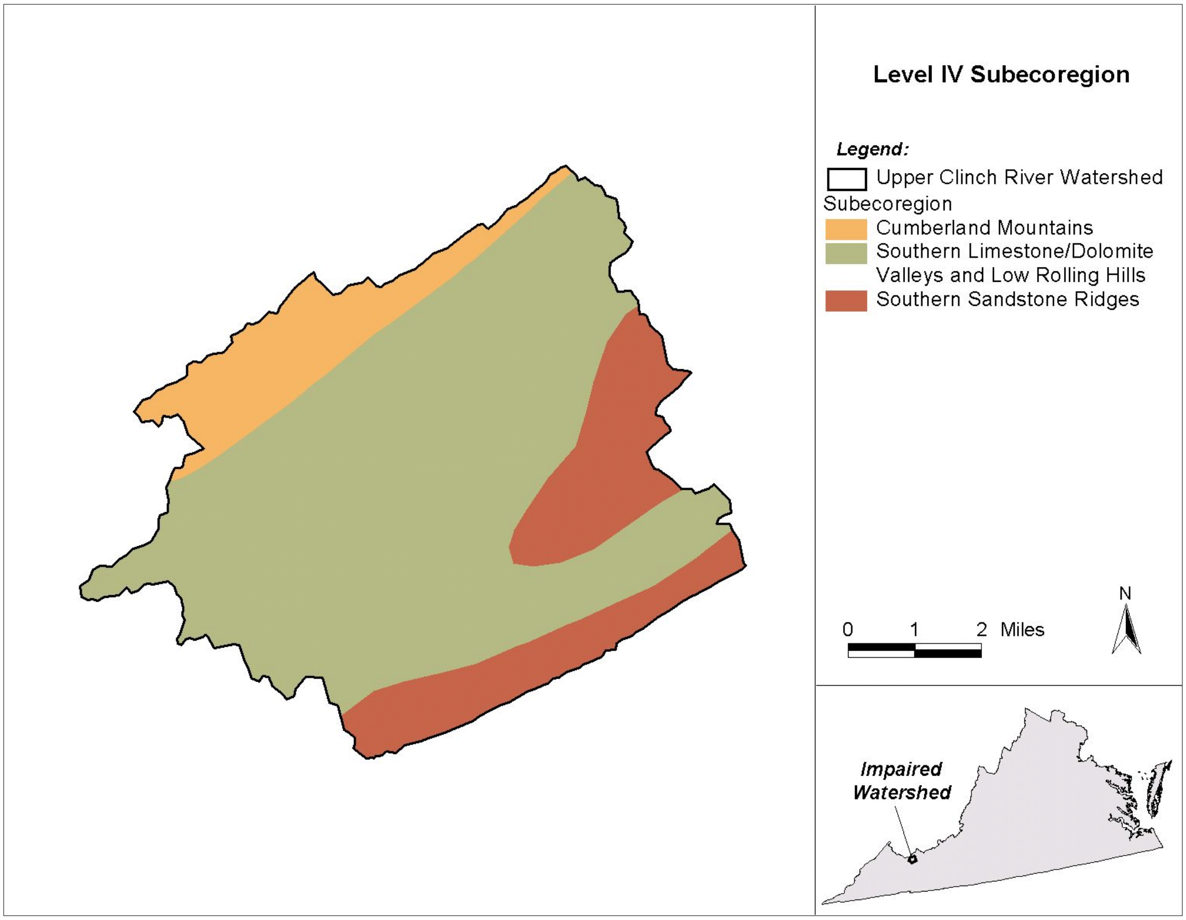

Figure 2.3 Level IV ecoregions in the Upper Clinch River watershed

2.3 Reference Watershed Selection

The reference watershed selection process is based on a comparison of key watershed, stream and biological characteristics. The goal of the process is to select one or several similar, unimpaired reference watersheds that can be used to identify benthic community stressors and develop TMDL endpoints. Reference watershed selection was based on the results of VADEQ biomonitoring studies and comparisons of key watershed characteristics. Data used in the reference watershed selection process for the Upper Clinch River are shown in Table 2.2.

Table 2.2 Reference watershed selection data

Biomonitoring Data	Ecoregion Coverages
Topography	Land use Distribution
Soils	Watershed Size
Water Quality Data	Point Source Inventory

Tetra Tech, VADEQ, and USEPA recently developed the Virginia Stream Condition Index (VaSCI), which provides a more detailed and reliable assessment of the benthic macroinvertebrate community in Virginia's non-coastal, wadeable streams (USEPA, 2003). This new multi-metric index, was used to compare relative differences in the benthic community between impaired and reference streams. This index allows for the evaluation of biological condition as a factor in the reference watershed selection process and can be used to measure improvements in the benthic macroinvertebrate community in the future. VADEQ biomonitoring data were used to calculate the VaSCI scores shown in Table 2.3. The Walker Creek scores are shown for comparison.

Table 2.3 Bioassessment index comparison

Station ID	Organization	Stream	Number of Samples	VaSCI Score
6BCLN346.80	DEQ	Upper Clinch River	2	58
Clinch1	GMU		1	58
Average				58
WLK050.85	DEQ	Walker Creek	2	75

2.4 Selected Reference Watershed

The Walker Creek watershed, delineated at the VADEQ biomonitoring station, was selected as the reference for this TMDL study (Figure 2.4). This determination was based on the degree of similarity between this stream and its associated watershed to the impaired stream and the results of the VaSCI scores. Figures 2.5, 2.6, and 2.7 show comparisons of the MRLC land use, soils, and subecoregion distributions within the Upper Clinch River watershed and the Walker Creek watershed.

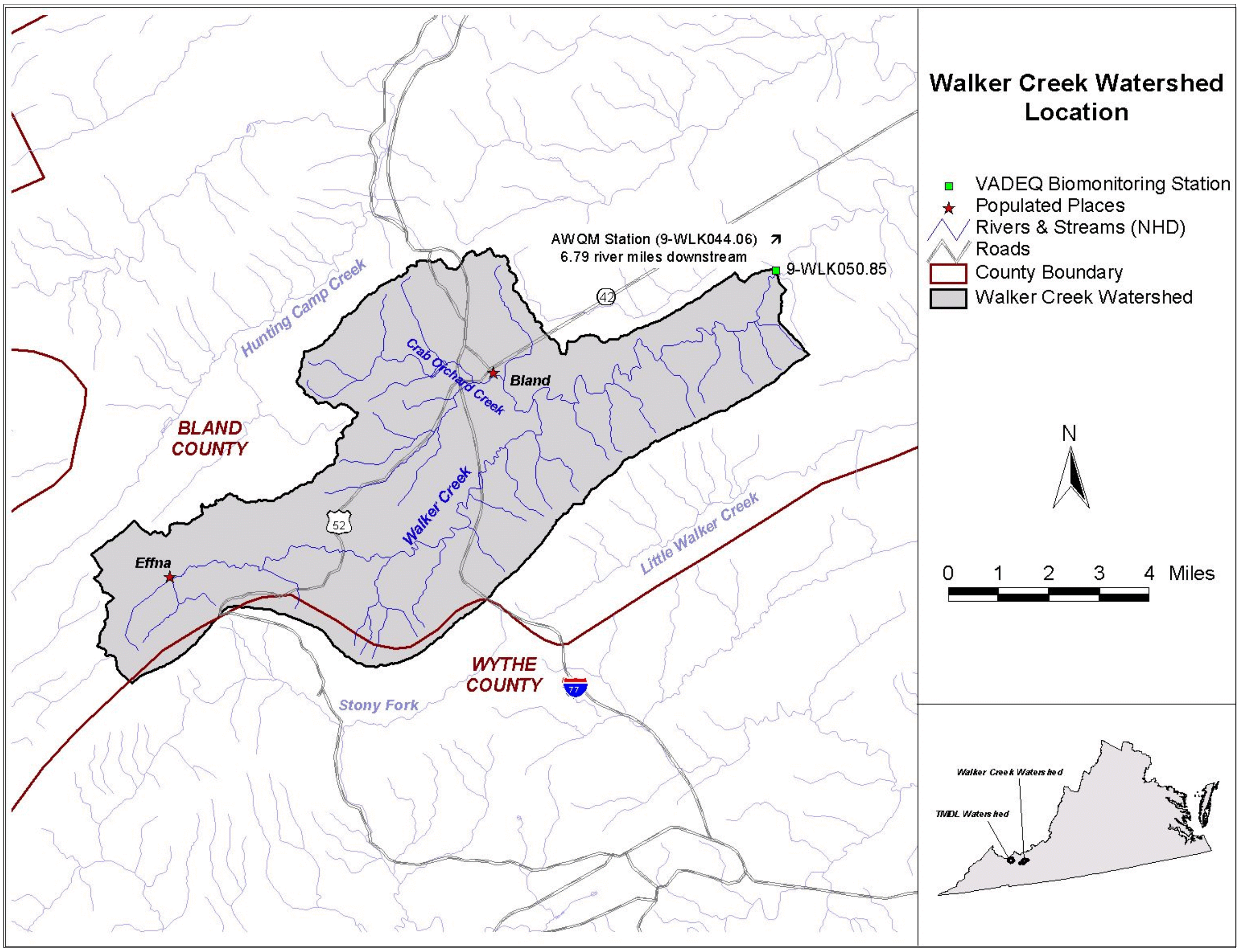

Figure 2.4 Reference watershed location and monitoring stations

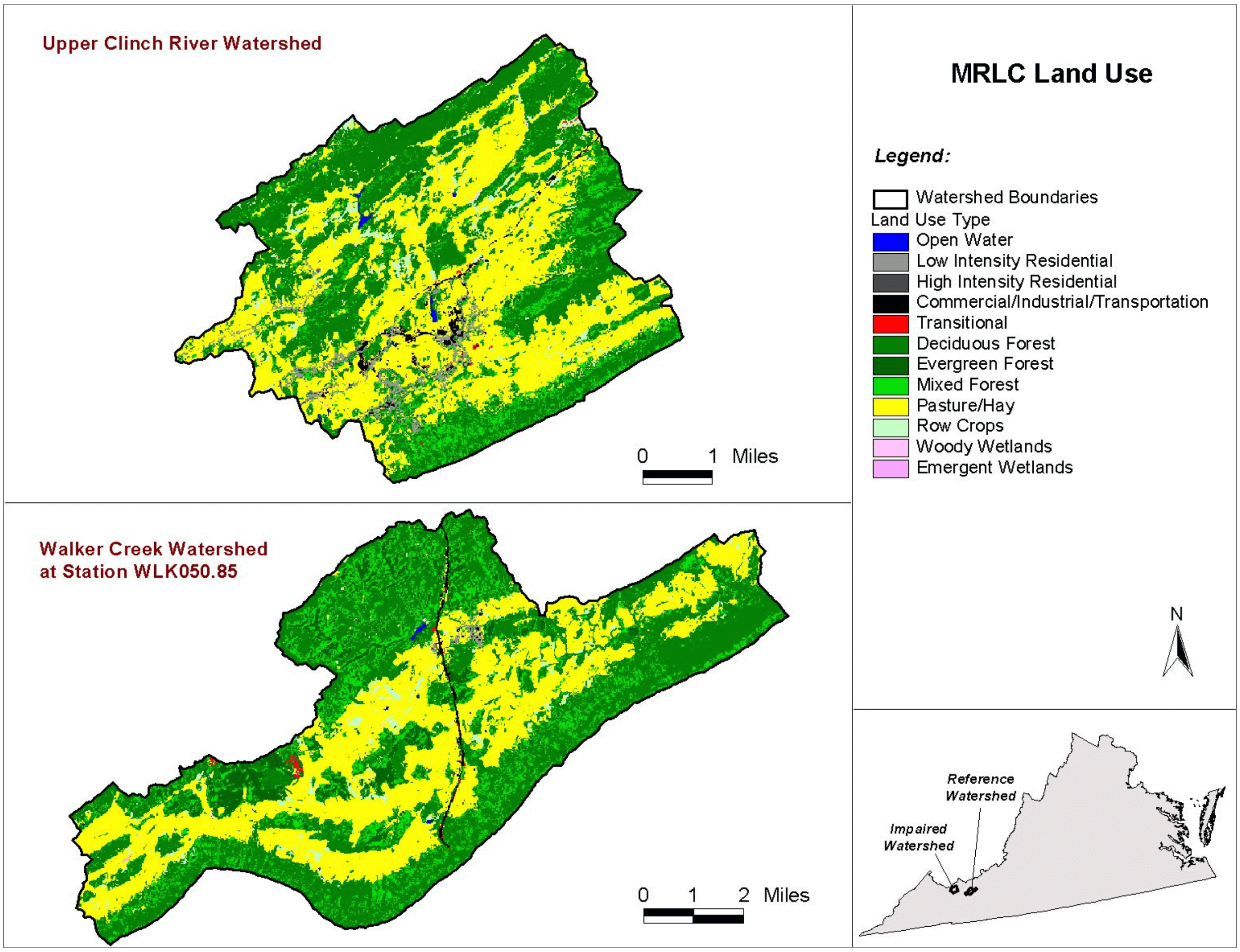

Figure 2.5 MRLC land use in the impaired and reference watersheds

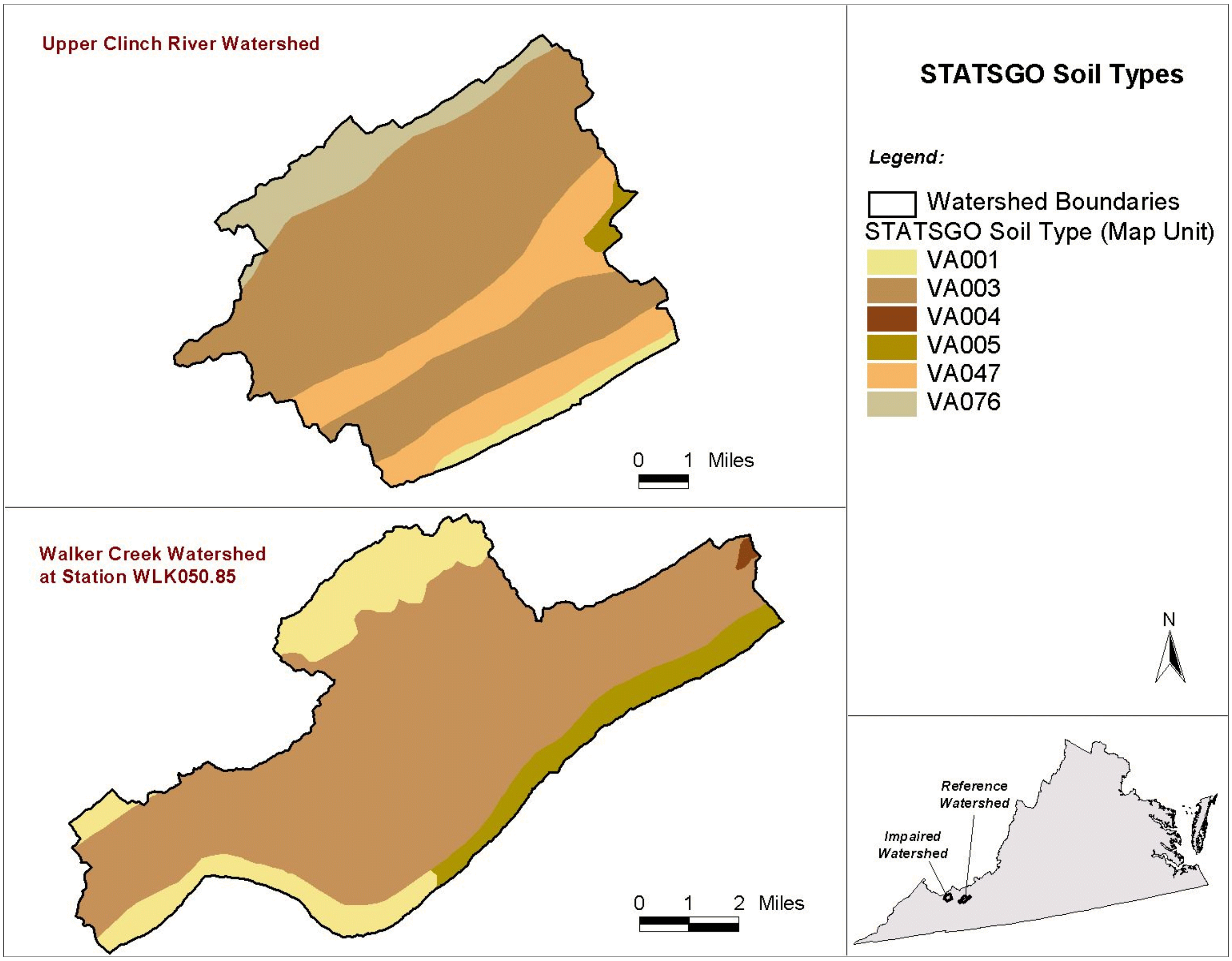

Figure 2.6 STATSGO soil types in the impaired and reference watersheds

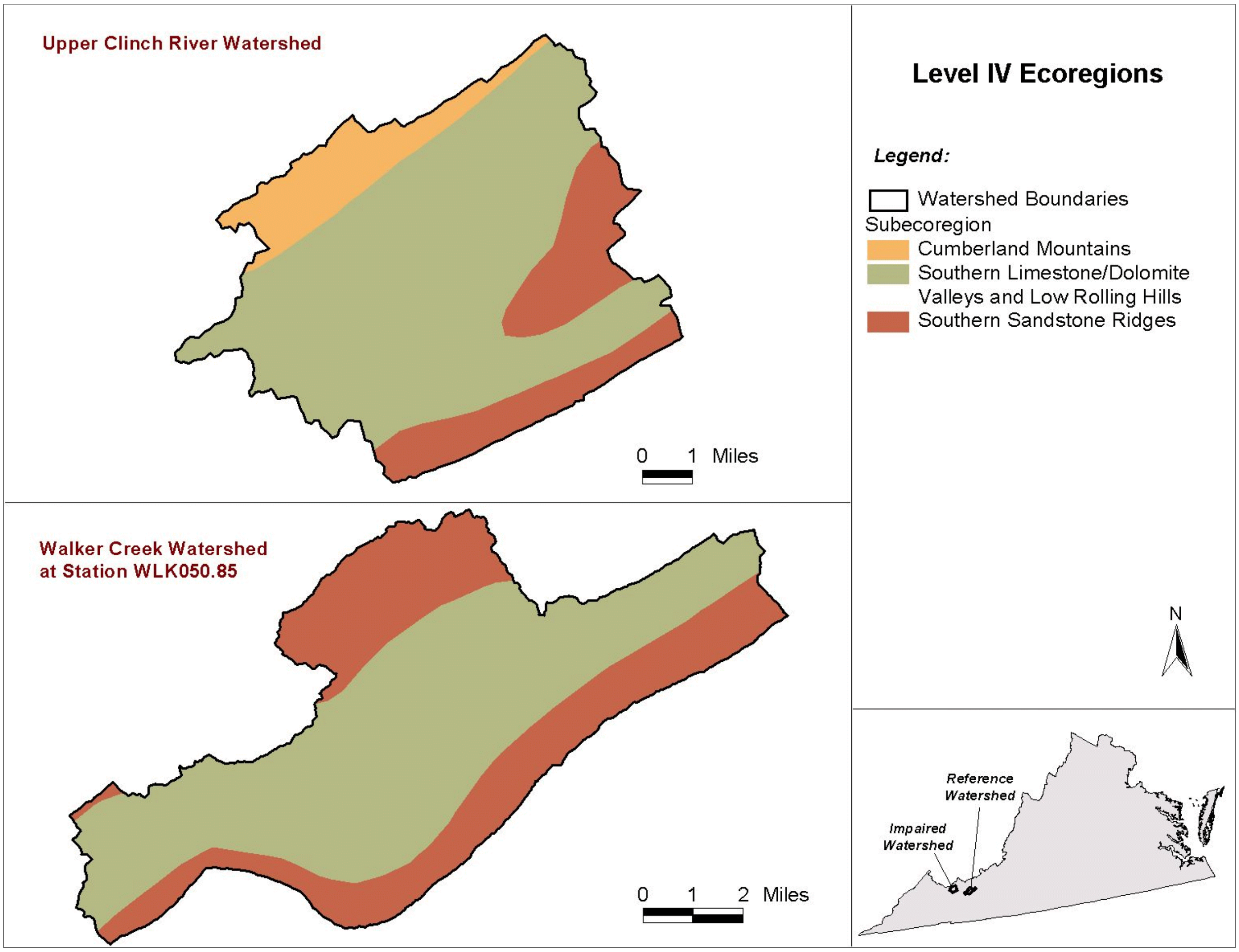

Figure 2.7 Level IV ecoregions in the impaired and reference watersheds

SECTION 3

STRESSOR IDENTIFICATION

3.1 Stressor Identification Process

Biological assessments are useful in detecting impairment, but they do not necessarily identify the cause(s) of impairment. EPA developed the *Stressor Identification: Technical Guidance Document* to assist water resource managers in identifying stressors or combinations of stressors that cause biological impairment (Cormier et al. 2000). Elements of the stressor identification process were used to evaluate and identify the primary stressors of the benthic community in the Upper Clinch River. Watershed and water quality data from these streams, reference watershed data, and field observations were used to help identify candidate causes.

3.2 Candidate Causes

Based on information provided by VADEQ and watershed data collected at the beginning of the TMDL study, it was hypothesized that excessive sedimentation was responsible for the listed benthic impairments. Field visits to the Upper Clinch River were conducted by Tetra Tech, GMU, and VADEQ personnel on April 10 and June 24, 2003 to gather information on stream and watershed characteristics for stressor identification and modeling studies. Field observations confirmed the likelihood that sedimentation was primarily responsible for negative impacts to the benthic macroinvertebrate community in this stream. Potential stressors and their relationships to benthic community condition are discussed below.

3.2.1 Low Dissolved Oxygen

Organic enrichment can cause low dissolved oxygen (DO) levels which stress benthic organisms. In general, high nitrogen and phosphorus levels can lead to increased production of algae and macrophytes, which can result in the depletion of oxygen in the water column through metabolic respiration. In addition, at higher water temperatures the concentration of dissolved oxygen is lower because the solubility of oxygen (and other gases) decreases with increasing temperature. Higher water temperatures can be caused by the loss of shading, higher evaporation rates, reduced stream flow, and other factors.

Aquatic organisms, including benthic macroinvertebrates, are dependent upon an adequate concentration of dissolved oxygen. Less tolerant organisms generally cannot survive or are outcompeted by more tolerant organisms under low dissolved oxygen conditions. This process reduces diversity and alters community composition from a natural state. Aquatic insects and other benthic organisms serve as food items for fishes, therefore, alterations in the benthic community can impact fish feeding ecology (Hayward and Margraf 1987; Leach et al. 1977).

3.2.2 Sedimentation

Excessive sedimentation from anthropogenic sources is a common problem that can impact the stream biota in a number of ways. Deposited sediments reduce habitat complexity by filling pools, critical riffle areas, and the interstitial spaces used by aquatic invertebrates. Substrate size is a particularly important factor that influences the abundance and distribution of aquatic insects. Sediment particles at high concentrations can directly affect aquatic invertebrates by clogging gill surfaces and lowering respiration capacity. Suspended sediment also increases turbidity in the water column which can affect the feeding efficiency of visual predators and filter feeders. In addition, pollutants, such as phosphorus, adsorb to sediment particles and are transported to streams through erosion processes.

3.2.3 Habitat Alteration

The relative lack of riparian vegetation along sections of these streams was considered to be a potential factor affecting the benthic community. Minimal riparian vegetation was observed in specific areas during the TMDL field visit. In this watershed, riparian areas are often used to grow crops and as pasture for livestock. Riparian areas perform many functions that are critical to the ecology of the streams that they border. Functional values include:

- Flood detention
- Plant roots stabilize banks and prevent erosion
- Nutrient cycling
- Wildlife habitat
- Canopy vegetation provides shading (decreases water temperature and increases baseflow through lower evaporation rates)

3.2.4 Toxic Pollutants

Toxic pollutants in the water column and sediment can result in acute and chronic effects on aquatic organisms. Increased mortality rates, reduced growth and fecundity, respiratory problems, tumors, deformities, and other consequences have been documented in toxicity studies of aquatic organisms. Degraded water quality conditions and other environmental stressors can lead to higher rates of incidence of these problems.

3.3 Monitoring Stations

There is one VADEQ biomonitoring station located in the Upper Clinch River watershed on the impaired segment at River Jack (6BCLN346.80). The closest water quality monitoring station (6BCLN339.53) is located approximately 7 miles downstream of the impaired segment. As part of the benthic TMDL study, George Mason University (GMU) personnel conducted water quality and biomonitoring at four stations in the Upper Clinch River watershed. Two stations are located on the mainstem (ClinchWQ1 & ClinchWQ4), one station is located at the mouth of the North Fork Clinch River (ClinchWQ2) and one station is located at the mouth of the South Fork Clinch River (ClinchWQ3). ClinchWQ1 is co-located with VADEQ biomonitoring station 6BCLN346.80. Benthic samples collected at GMU stations ClinchWQ2, ClinchWQ3, and ClinchWQ4 are currently being processed. All of the monitoring stations located in the Upper Clinch River watershed are listed in Table 3.1 and shown in Figure 3.1.

Table 3.1 Monitoring stations on the Upper Clinch River

Stream	Station	Organization	Location	Data Period
Clinch River	6BCLN339.53	VADEQ	Rt. 637 bridge, just downstream of the impaired segment	1992-2001
Clinch River	6BCLN346.80	VADEQ	Off Rt. 16, off Broadway Street	1995-1997
Clinch River	ClinchWQ1	GMU	Clinch River @ Rt. 16 Alt (Ron's Kwik Stop/River Jack)	2003
North Fork Clinch River	ClinchWQ2	GMU	North Fork Clinch River @ Rt. 61 (Fourway)	2003
South Fork Clinch River	ClinchWQ3	GMU	South Fork Clinch River @Rt.19 (Fourway Hardee's)	2003
Clinch River	ClinchWQ4	GMU	Clinch River off Industrial Rd. ½ mi below confluence of North and South Forks	2003

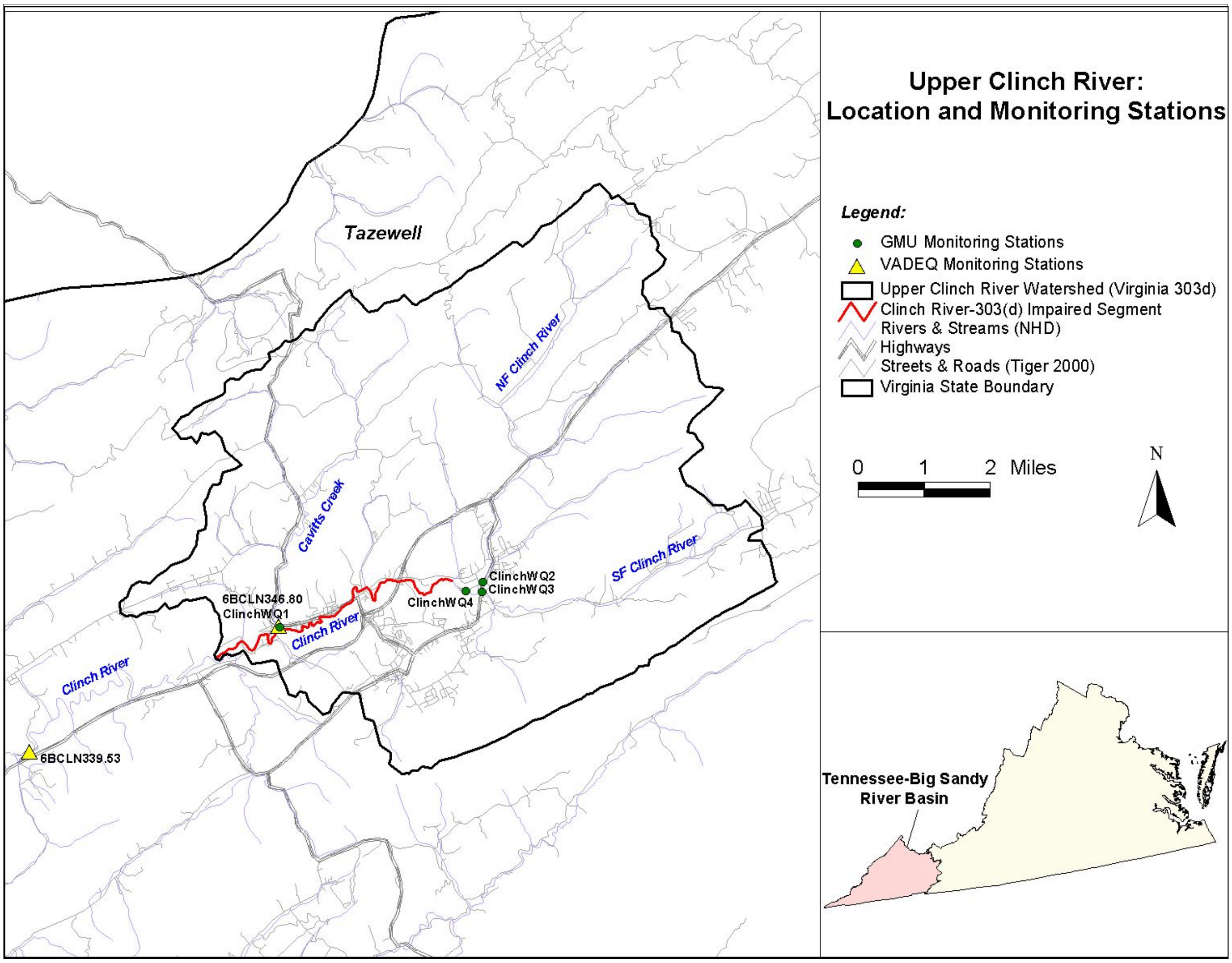

Figure 3.1 Location of the Upper Clinch River monitoring stations

3.4 Monitoring Data Summary

3.4.1 Water Quality Criteria

The Upper Clinch River is classified as a Mountainous Zone waterbody (Class IV) in Virginia's Water Quality Standards (9 VAC 25-260-50). Numeric criteria for dissolved oxygen (DO), pH, and maximum temperature for Class IV waters are shown in Table 3.2.

Table 3.2 Virginia numeric criteria for Class IV waters

Dissolved Oxygen (mg/L)		pH (standard units)	Maximum Temperature (^oC)
Minimum	Daily Average		
4	5	6.0 - 9.0	31

Data collected on the Upper Clinch River and tributaries include VADEQ Ambient Water Quality Monitoring (AWQM) data, VADEQ biomonitoring data, and George Mason University water quality and biomonitoring data. VADEQ AWQM data are typically collected on a monthly basis and biomonitoring data are typically collected in the spring and fall of each year. GMU personnel collected water quality and biomonitoring data April 10 and June 24, 2003.

3.4.2 Water Quality Summary Plots

Selected parameters were plotted to examine spatial trends and to compare to reference stream conditions. Water quality monitoring data collected by VADEQ and GMU are shown in a time-series format for a period of record that includes data from 1985 onwards (Figures 3.2 through 3.16). Time-series plots show all the individual observations over the period of record for each station. Water quality data collected during biomonitoring field visits were not included in these plots.

*Note that GMU water quality data were added to the VADEQ data set for each station because of the approximate co-location of VADEQ and GMU monitoring stations on both streams. Stations are identified using VADEQ station codes in each plot. Time-series plots show the individual observations for all VADEQ and GMU data.

Dissolved Oxygen

Figure 3.2 presents DO values recorded at Upper Clinch River stations. DO concentrations measured at VADEQ and GMU monitoring stations were above established criteria. The lowest measurements were recorded at VADEQ station 6BCLN339.53.

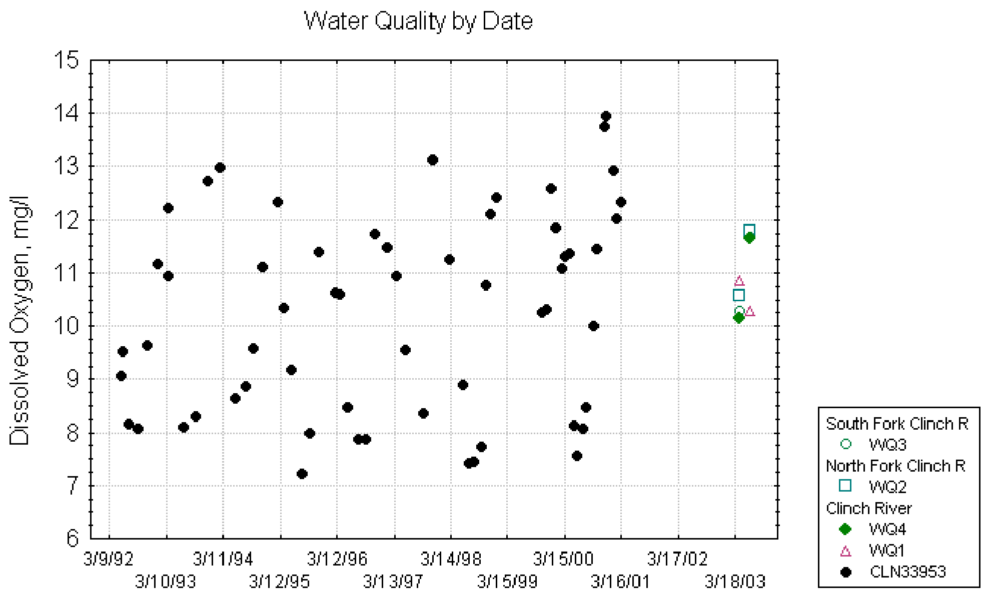

Figure 3.2 Time-series DO values for Upper Clinch River stations

Water Temperature

Surface water temperature data for all monitoring stations are shown in Figure 3.3. All observations were well below the Class IV maximum criteria (31 degrees Celsius).

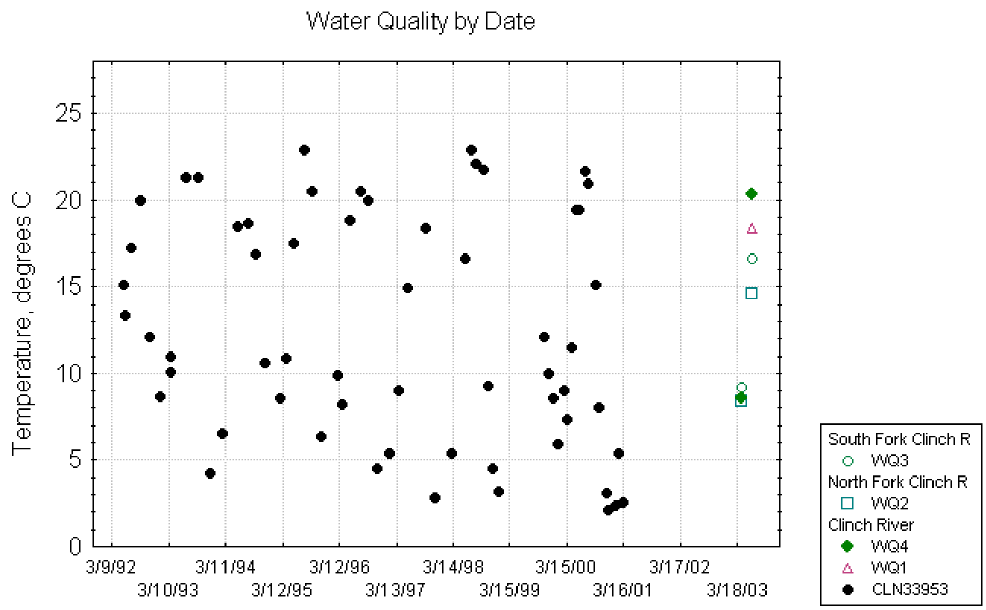

Figure 3.3 Time-series temperature values for Upper Clinch River stations

pH

pH data for the Upper Clinch River watershed are shown in Figure 3.4. All pH values were within the acceptable Class IV range (6.0 – 9.0 standard units). The majority of the pH data for VADEQ station 6BCLN339.53 were between the range of 7.5 to 8.5.

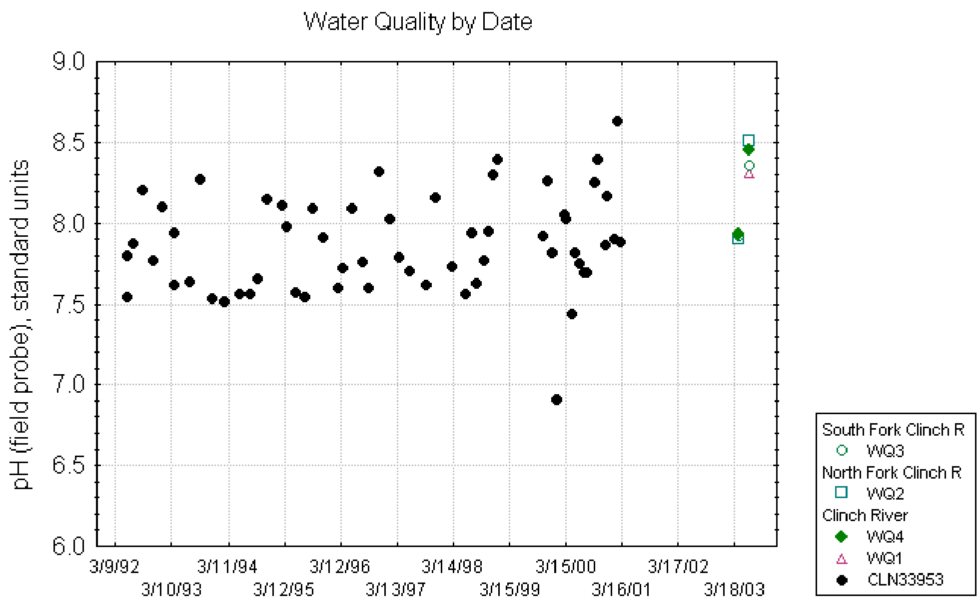

Figure 3.4 Time-series pH values for Upper Clinch River stations

Conductivity (Specific Conductance)

Conductivity data are presented in Figure 3.5. The highest single observation was above 380 umhos at station 6BCLN339.53. Conductivity measurements were below 320 umhos at all other monitoring stations.

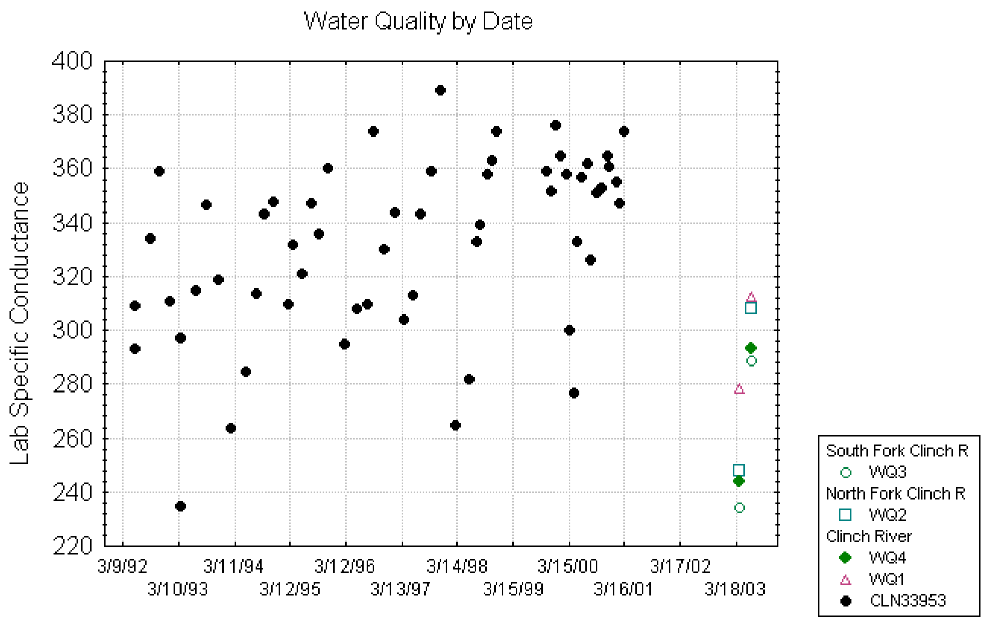

Figure 3.5 Time-series lab conductivity values for Upper Clinch River stations

BOD5

BOD5 is the biochemical oxygen demand measured over five days. It indicates the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter. High BOD can be caused by organic pollution and high nitrate levels, and results in reduced DO. Therefore, BOD5 can serve as an index of the degree of organic pollution. BOD5 data for the Upper Clinch River are presented in Figure 3.6. There is only one measurement above 2.0 mg/L for the period of record (VADEQ station 6BCLN339.53).

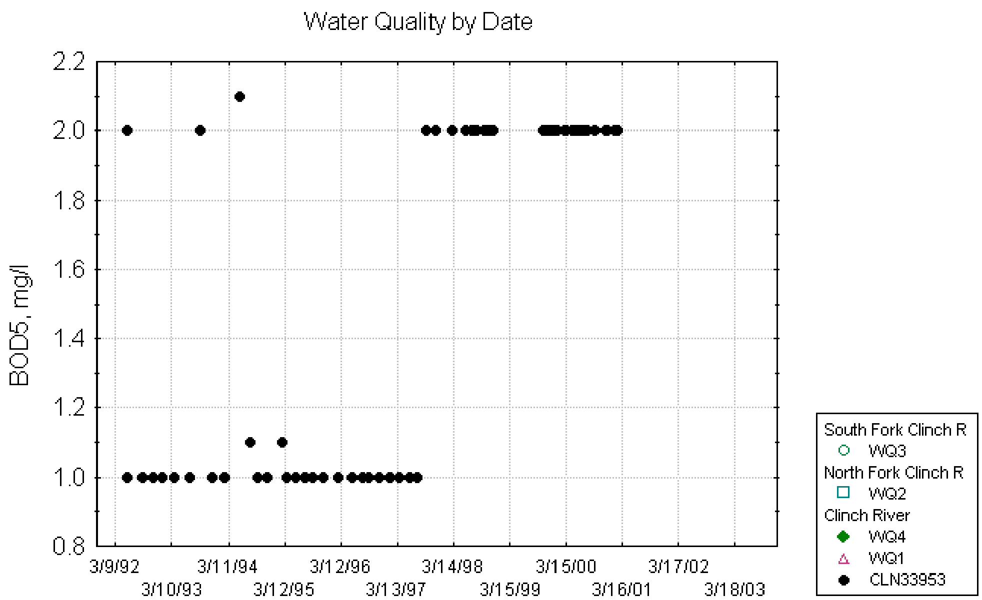

Figure 3.6 Time-series BOD5 values for Upper Clinch River stations

Phosphorus

Phosphorus is generally present in waters and wastewaters in different species of soluble (dissolved) and insoluble (particulate or suspended) phosphates, including inorganic (ortho- and condensed) phosphates and organic phosphates. Major sources of phosphorus include detergents, fertilizers, domestic sewage, and agricultural runoff. Total phosphorus and orthophosphate data are presented in Figures 3.7 and 3.8. All observations were below 0.2 mg/L. The highest observations were recorded at VADEQ station 6BCLN339.53. Data collected on the impaired segment or at upstream stations were below 0.16 mg/L. These data are considered to be within the range of expected background conditions for this stream type.

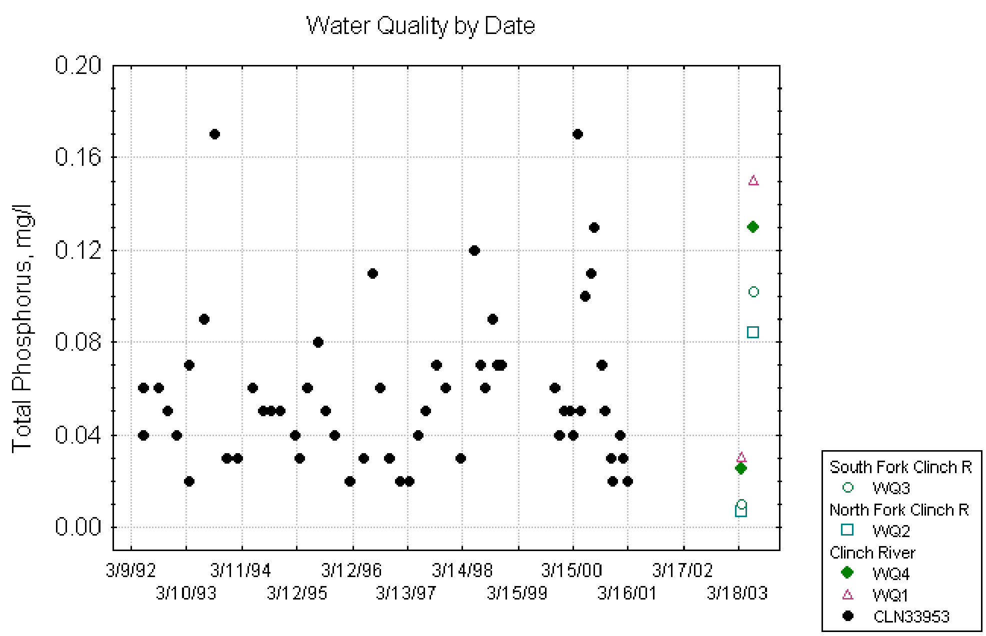

Figure 3.7 Time-series total phosphorus values for Upper Clinch River stations

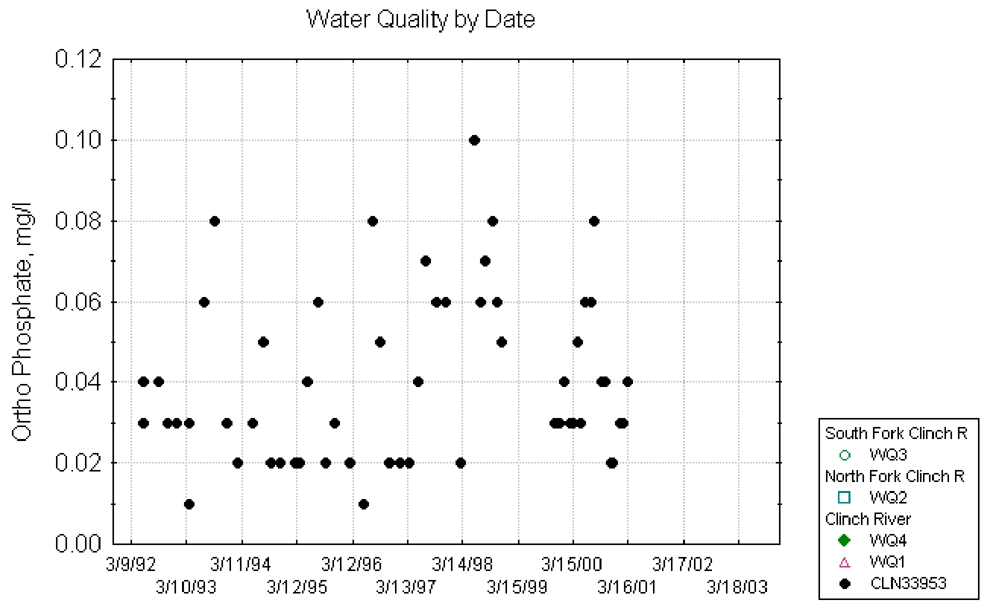

Figure 3.8 Time-series orthophosphate values for Upper Clinch River stations

Nitrogen

Major sources of nitrogen include municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes, runoff from fertilized agricultural field and lawns, and discharges from car exhausts. Nitrate and Nitrite data are presented in Figures 3.9 through 3.11. The highest single nitrate observation was recorded at GMU station ClinchWQ3. The majority of the nitrate data were below 1.6 mg/L. Nitrite data were also at low levels.

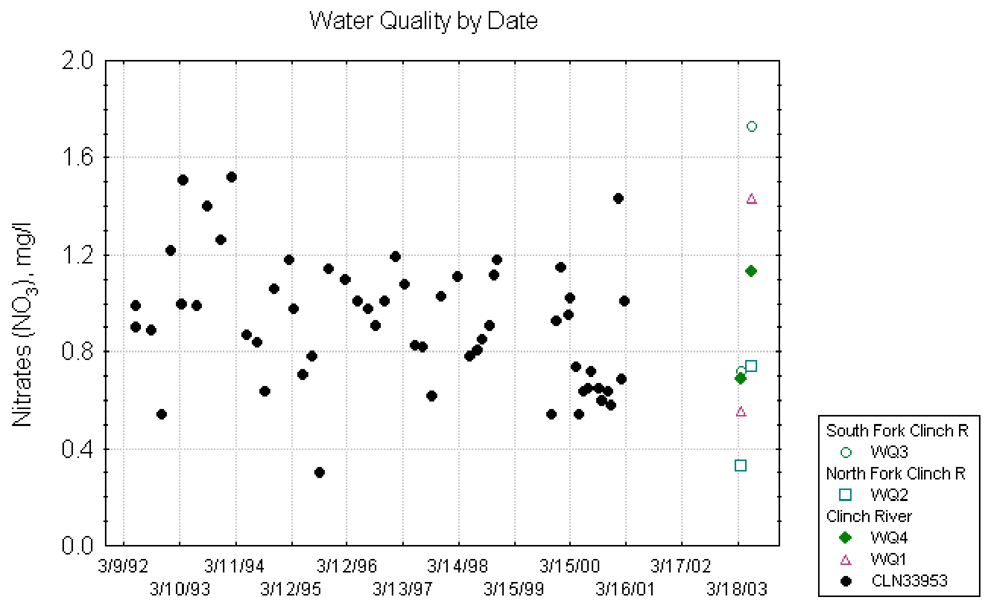

Figure 3.9 Time-series nitrate values for Upper Clinch River stations

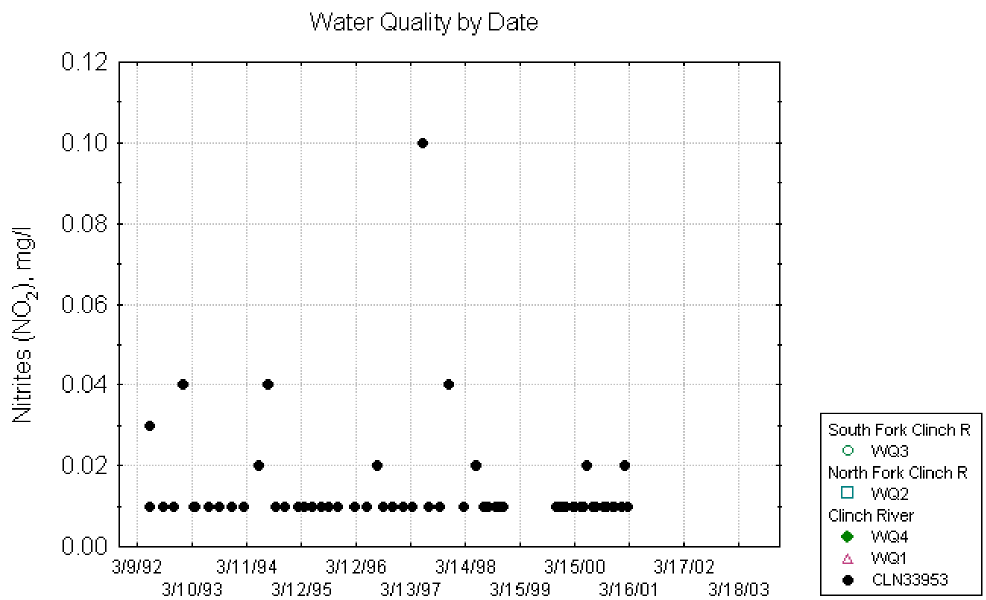

Figure 3.10 Time-series nitrite values for Upper Clinch River stations

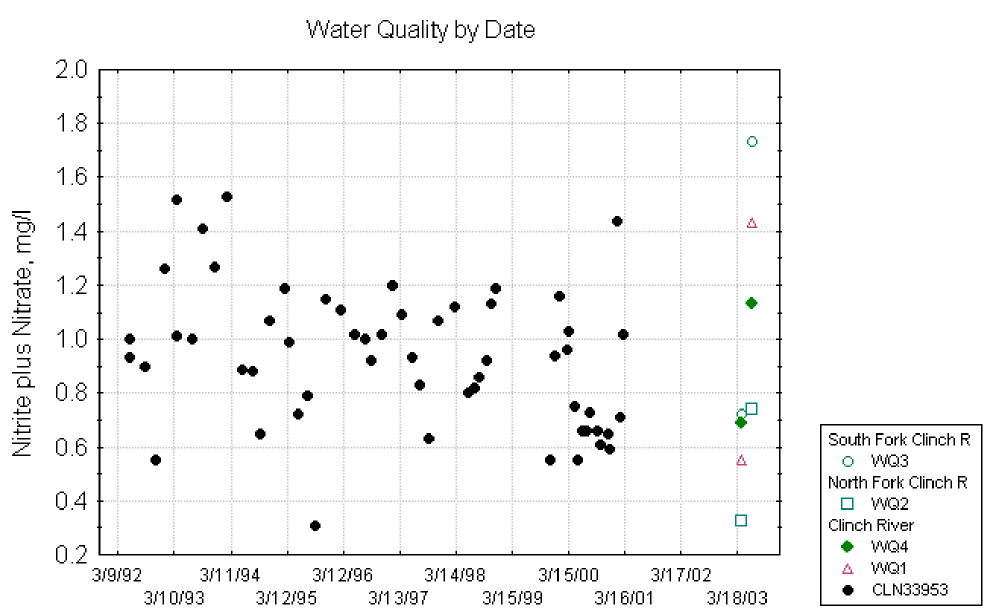

Figure 3.11 Time-series nitrite+nitrate values for Upper Clinch River stations

TKN data are presented in Figure 3.12.

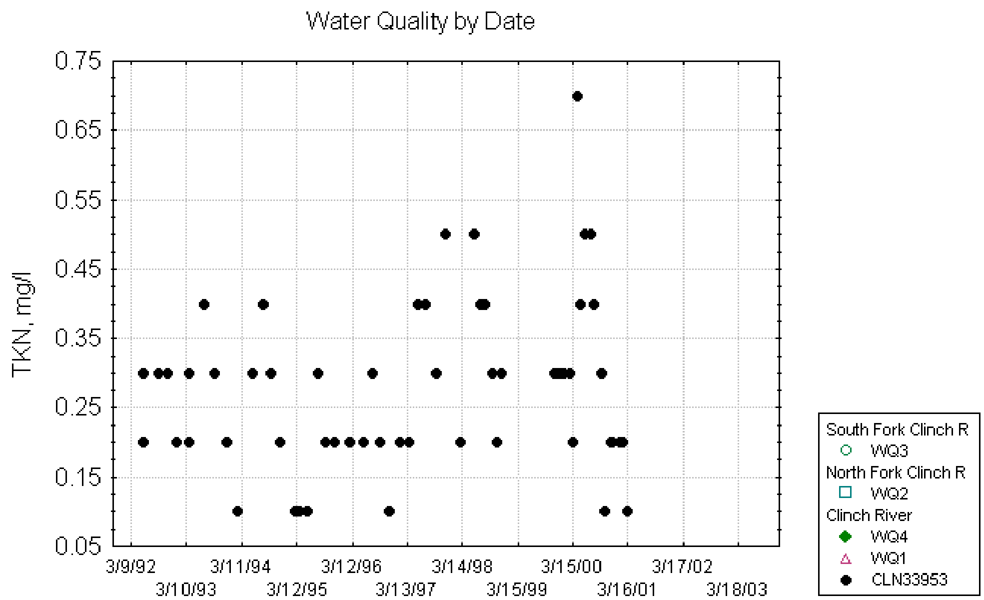

Figure 3.12 Time-series TKN values for Upper Clinch River stations

Ammonia is a critical component of the nitrogen cycle. At high concentrations, ammonia is toxic to aquatic life, depending on in-stream pH and temperature levels. In general, higher temperature and pH levels increase the toxicity of ammonia. Virginia Water Quality Standards (9 VAC 25-260-140) list acute and chronic criteria for ammonia. Figure 3.13 shows total ammonia (NH3+NH4) values for Upper Clinch River stations. There was only one total ammonia observation greater than 0.2 mg/L. All other ammonia data for the Upper Clinch River were below 0.15 mg/L. Ammonia is also discussed in Section 3.5 (Toxic Pollutants).

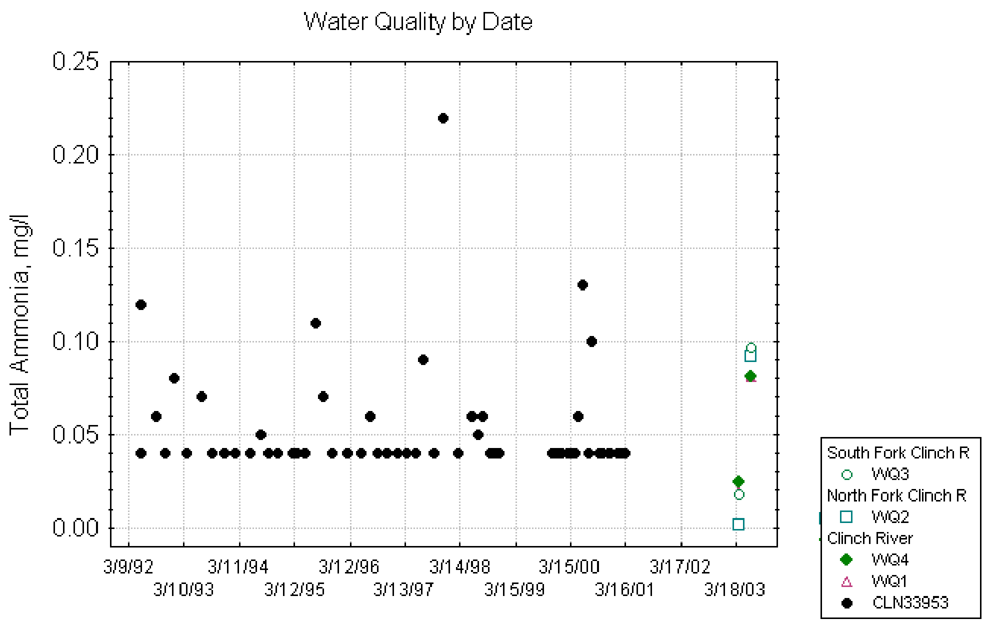

Figure 3.13 Time-series total ammonia values for Upper Clinch River stations

Nitrogen to Phosphorus ratios (N:P)

Based on available water quality data, nitrogen to phosphorus ratios were calculated for each water quality station to determine the limiting nutrient in the Upper Clinch River watershed (Figure 3.14). An N:P ratio greater than 10 typically indicates a phosphorus limited system; while a ratio of less than 10 indicates a nitrogen limited system. The majority of the calculated N:P ratios were above 10, which is generally indicative of a phosphorus-limited stream.

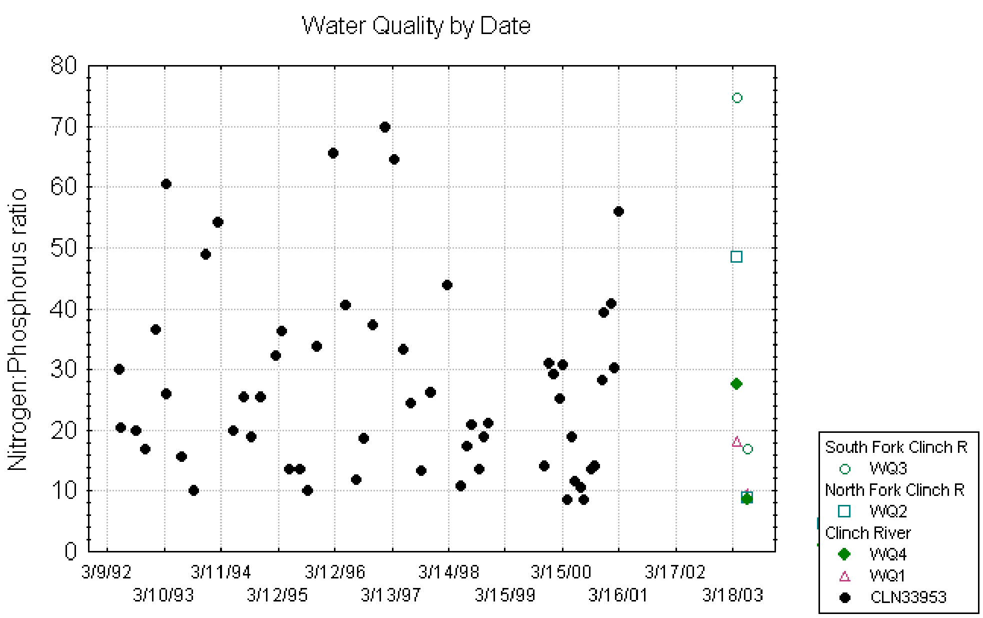

Figure 3.14 Time-series N:P ratios for Upper Clinch River stations (available nitrogen and phosphorus species data used to calculate N:P ratios)

Total Suspended Solids and Turbidity

Total suspended solids (TSS) and turbidity data were used to help examine possible sedimentation impacts on the benthic macroinvertebrate community (Figures 3.15 through 3.16). These sedimentation measurements were high on a few occasions, although the majority of the TSS data were below 20 mg/L for VADEQ station 6BCLN339.53.

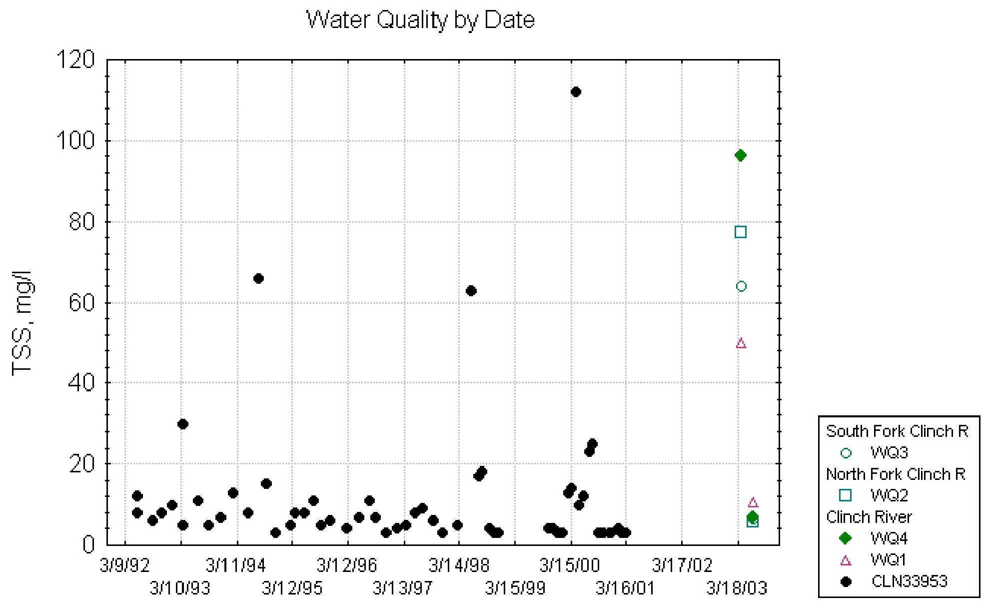

Figure 3.15 Time-series TSS values for Upper Clinch River stations

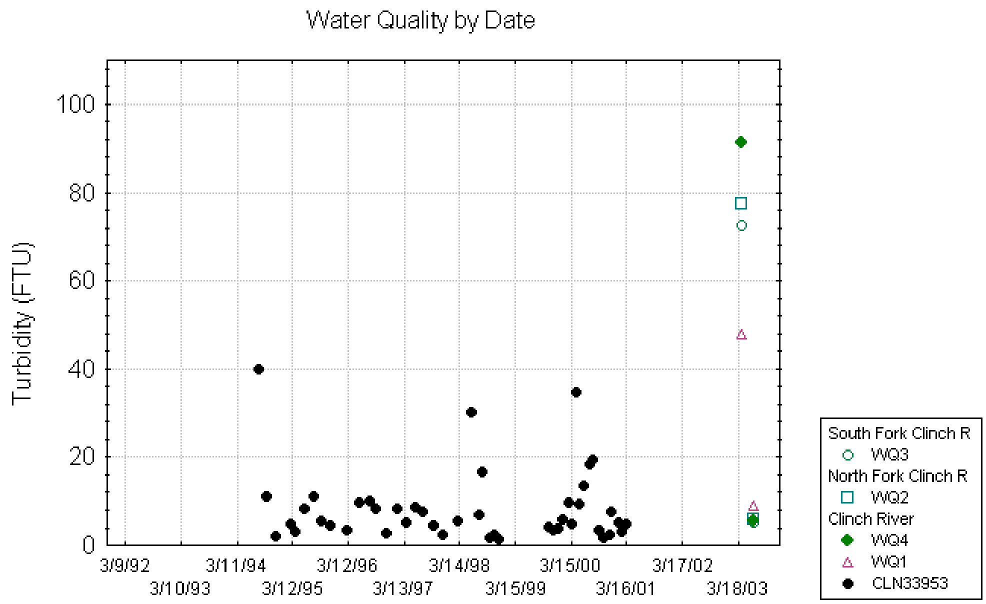

Figure 3.16 Time-series turbidity values for Upper Clinch River stations

Station 6BCLN339.53 often showed the poorest water quality of all sampling stations on the Upper Clinch River. This station had the highest total phosphorus and ortho-phosphate, total ammonia, and TSS concentrations and recorded the lowest pH and DO levels. It should be noted that this was the only station on the Upper Clinch river that was sampled for multiple years. Land use in the Upper Clinch River watershed is shown in Section 2. The watershed primarily consists of forest land and pasture/hay land, although the impaired stream flows through River Jack and Tazewell.

3.4.3 DO Analysis

Primary producers (algae and macrophytes) produce oxygen during the day through photosynthesis and use oxygen at night through respiration. This diel photosynthesis/respiration cycle results in higher DO concentrations during the day and lower concentrations at night. DO data collected at stations in the Upper Clinch River watershed were compared to the daily average (5.0 mg/L) and minimum (4 mg/L) DO criteria listed in Virginia's Water Quality Standards to help determine if DO conditions are considered to be a primary cause of the benthic impairment (Figure 3.2). DO concentrations measured at VADEQ and GMU monitoring stations were above established criteria. The lowest measurements were recorded at VADEQ station 6BCLN339.53. To further assess DO conditions in Upper Clinch River, VADEQ measured DO at station 6BCLN346.80 in the early morning hours on September 4, 2002 (Table 3.3). DO concentrations during this sampling event were also greater than the daily average and minimum DO criteria.

Table 3.3 VADEQ Diurnal DO study (September 2002)

Station	Date/Time	Temperature (Celsius)	PH (std. units)	Conductivity (umhos)	DO (mg/L)
6BCLN346.80	9/4/02 5:50am	19.8	7.63	338	6.77
6BCLN346.80	9/4/02 6:45am	19.7	7.64	338	6.73
6BCLN346.80	9/4/02 7:45am	19.6	7.66	338	6.74

3.4.4 Biomonitoring Data

Available biomonitoring data were summarized to help characterize the benthic community in the Upper Clinch River. The Virginia Stream Condition Index (VaSCI) was used to assess the biological community in each stream. The benthic multimetric scores provided by this index allow for a more detailed and reliable assessment of the benthic macroinvertebrate community. VADEQ and GMU biomonitoring data were used to calculate the VaSCI score for the biomonitoring station (Table 3.4). Data for GMU sampling sites are included in the scores based on correspondence with VADEQ station locations. These scores are lower than comparable scores at several reference stations in the region.

Table 3.4 VaSCI standardized scores for the Upper Clinch River

Station ID	Organization	Stream	Sample Date	VaSCI Index Score
6BCLN346.80	VADEQ	Upper Clinch River	5/9/95	62
			6/25/97	54
Clinch1	GMU		6/24/03	58
Average				58

Taxa data collected by GMU personnel in June of 2003 are shown in Table 3.5. This table includes data for one site on the Upper Clinch River. Samples from other sites in the watershed are currently being processed. The high number of chironomids, oligochaetes, and gastropods indicate excessive sedimentation and corresponding habitat problems.

Table 3.5 GMU macroinvertebrate assessment

Site ID		**ClinchWQ1**
Stream name		Clinch River
Site location brief description		At Rt. 16 Alt
Corresponding DEQ station		Upstream of 6BCLN346.80
Date		6/24/2003
Organisms Identified		**Count**
Order	**Family**	
Ephemeroptera (Mayflies)	unspecified	4
	Tricorythidae	4
	Siphlonuridae	1
	Palingeniidae	3
Plecoptera (Stoneflies)	Perlidae	1
Diptera (True flies)	Chironomidae (midges)	32
	Tipuliidae (crane flies)	4
	Tabnidae (Horse/Deer flies)	7
Coleoptera (Water Beetles)	Elmidae	48
	Psephenidae	24
Odonata (Dragonflies & Damselflies)	Gomphidae (Clubtails)	3
Hemiptera (Waterbugs)		
P. Annelida	C. Oligochaeta (Earthworms)	45
P. Mollusca	C. Gastropoda (Snails)	36
Total		212

3.4.5 Rapid Bioassessment Protocol - Habitat Data

Rapid Bioassessment Protocol (RBP) habitat data for Upper Clinch River VADEQ and GMU biomonitoring stations are shown in Tables 3.6 and 3.7. These data were used to examine possible sedimentation and other habitat impacts to the benthic community, along with the TSS and turbidity data discussed above. All habitat scores were evaluated and rated by observation (0-20, with higher scores being better). The following parameters are included in the habitat assessment for the Upper Clinch River:

- Channel alteration – measure of large-scale changes in the shape of the stream channel
- Bank condition/stability – whether the stream banks are eroded (or have the potential for erosion)
- Bank vegetative protection – the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone
- In-stream cover (for fish)
- Embeddedness – extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom
- Channel flow status – degree to which the channel is filled with water

- Grazing or other bank disruptive pressure
- Frequency of riffles
- Riparian vegetation zone width – width of natural vegetation from the edge of the stream bank out through the riparian zone
- Sediment deposition – amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition
- Epifaunal substrate – relative quantity and variety of natural structures in the stream for spawning and nursery functions of aquatic macrofauna
- Velocity/depth regimes

Table 3.6 VADEQ RBP habitat scores for Upper Clinch River

StationID	CollDate	Total Habitat Score	Bank condition	Bank vegetative protection	Channel alteration	Channel flow status	Embed-dedness	Epifaunal substrate	Grazing/ bank disruptive pressure	Instream Cover	Riffle frequency of stream	Riparian zone width	Sediment deposition	Velocity-depth regimes
CLN346.80	05/09/1995	158	10	18	18	18	9	14	12	16	9	8	13	13
CLN346.80	06/25/1997	111	7	18	18	17	7	3	9	4	3	8	11	6

Table 3.7 GMU RBP habitat scores for Upper Clinch River

StationID	CollDate	Total Habitat Score	Bank Stability	Vegetative Protection	Channel Alteration	Channel Flow Status	Embed-dedness	Epifaunal substrate/ Available cover	Frequency of Riffles	Riparian Vegetative Zone Width	Sediment Deposition	Velocity/ Depth Regime
ClinchWQ1	6/24/2003	103	6	6	11	19	7	11	15	6	9	13

3.5 Toxic Pollutants - Surface Water

Virginia Water Quality Standards list acute and chronic criteria for surface waters (9 VAC 25-260-140). These numeric criteria were developed for metals, pesticides, and other toxic chemicals which can cause acute and chronic toxicity effects on aquatic life and human health. Available water quality data were compared to these criteria to determine possible effects on aquatic life. Ammonia data collected on the Upper Clinch River (see Section 3.4.2, Figure 3.13) were compared to the calculated acute and chronic criteria. No exceedances were noted. All other available water quality data were compared to these criteria to determine possible effects on aquatic life and there were no violations of water column metals criteria.

3.6 Toxic Pollutants - Sediment

Virginia's Water Quality Standards and updated 305(b) assessment guidance for sediment parameters were consulted to determine if the available data indicate high levels for metals, pesticides, or other constituents that can cause acute or chronic toxicity effects on aquatic life. Sediment data were assessed using EPA Probable Effects Concentration (PEC) thresholds and the NOAA Effects Range-Median (ER-M) and Effects Range-Low (ER-L) screening values. Sediment parameter data are presented in Table 3.8. Recorded detection limits and off-scale low values (known to be less than the value shown) are referenced in the table (STORET remark codes U and K, respectively).

VADEQ uses the Probable Effects Concentration (PEC) criteria to help determine possible toxic effects to aquatic life (2002 305(b) water quality assessment guidance). The PEC criteria for Total PCBs was exceeded on July 13, 1998. The monitoring station is located 7.26 miles downstream of the VADEQ biomonitoring station. All previous measurements were at or below the analysis detection limit (six observations from July 6, 1992 - May 28, 1997).

Table 3.8 Sediment parameter exceedances
* Bolded threshold levels were exceeded on at least one occasion

Parameter	Date	Value	PEC	ER-M	ER-L
VADEQ station 6BCLN339.53					
PCB Total (ppb) - 7 total samples (not incl . duplicates): 7/6/92 – 7/13/98 - 6 samples below detection limit, all prior to 1998	7/13/98	720	**676**	**180**	**22.7**
Nickel (ppm) - 6 total samples: 6/14/93 – 7/13/98 - 3 samples < ER-L - Recent sample: 7/13/98 16.2 ppm	6/14/93	29	48.6	51.6	**20.9**
	7/10/96	27			
	5/28/97	21			
Zinc (ppm) - 6 total samples: 6/14/93 – 7/13/98 - 5 samples < ER-L, all recent observations	6/14/93	260	459	410	**150**

3.7 EPA Toxicity Testing

A chronic toxicity study using fathead minnows (*Pimephales promelas*) and *Ceriodaphnia dubia* was conducted on ambient water samples collected from the Upper Clinch River on January 27-29, 2003. Test results did not indicate an acute or chronic toxic response in the bioassay organisms.

3.8 Summary

Based on the above analysis, it is hypothesized that excessive sedimentation from non-point source inputs is primarily responsible for the benthic impairment in Upper Clinch River. Metals data (water column and sediment) do not indicate possible metals toxicity effects. An exceedance of the PEC criterion for total PCBs was measured on July 13, 1998 at VADEQ station 6BCLN339.53. This station is located 7.26 miles downstream of the VADEQ biomonitoring station 6BCLN346.80. All previous Total PCB measurements were at or below the analysis detection limit. Follow-up monitoring (at both VADEQ monitoring stations) is needed to confirm whether a Total PCB problem exists. EPA toxicity test results were negative. DO concentrations are adequate to support aquatic life; therefore, nutrient (phosphorus) reductions do not appear to be required.

SECTION 4

SOURCE ASSESSMENT - SEDIMENT

Point and nonpoint sources of sediment were assessed in TMDL development. The source assessment was used as the basis of model development and analysis of TMDL allocation options. A variety of information was used to characterize sources in impaired and reference watersheds including: MRLC land use/land cover data, water quality monitoring and point source data provided by VADEQ, STATSGO soils data (NRCS), site visit observations, literature sources, and other information. Procedures and assumptions used in estimating sediment sources in impaired and reference watersheds are described in the following sections. Whenever possible, data development and source characterization were accomplished using locally-derived information.

4.1 Assessment of Nonpoint Sources

Erosion of the land results in the transport of sediment to receiving waters through various processes. Factors that influence erosion include characteristics of the soil, vegetative cover, topography, and climate. Nonpoint sources, such as agricultural land uses and construction areas, are large contributors of sediment because the percentage of vegetative cover is typically lower. Urban areas can also contribute quantities of sediment to surface waters through the build-up and eventual washoff of soil particles, dust, debris, and other accumulated materials. Pervious urban areas, such as lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses. In addition, streambank erosion and scouring processes can result in the transport of additional sediment loads.

4.1.1 Agricultural Land

Agricultural land was identified as a primary source of sediment in the Upper Clinch River watershed. Agricultural runoff can contribute increased pollutant loads when farm management practices allow soils rich in nutrients from fertilizers or animal waste to be washed into the stream, increasing in-stream sediment and phosphorus levels. The erosion potential of cropland and over-grazed pasture land is particularly high due to the lack of year-round vegetative cover. The use of cover crops and other management practices have been shown to reduce the transport of pollutant loads from agricultural lands. Streambank erosion is also a potential source of sediment in agricultural watersheds, due to the removal of riparian vegetation and other factors. Bank stabilization measures and riparian plantings can significantly reduce streambank erosion.

MRLC land use coverages for the Upper Clinch River and Walker Creek are shown in Section 2.

4.1.2 Forest Land

Agricultural and urban development in these watersheds has replaced some mature forest areas, especially along the stream and at lower elevations. The sediment yield from undisturbed forest lands, especially during the growing season, is low due to the amount of dense vegetative cover which stabilizes soils and reduces rainfall impact.

4.1.3 Urban Areas

Urban land uses represented in the MRLC land use coverage include commercial, industrial, transportation, and residential areas. Urban land uses consist of pervious and impervious areas. Stormwater runoff from impervious areas, such as paved roads and parking lots, contribute pollutants that accumulate on these surfaces directly to receiving waters without being filtered by soil or vegetation. Sediment deposits in impervious areas originate from vehicle exhaust, industrial and commercial activities, outdoor storage piles, and other sources. In addition, stormwater runoff can cause streambank erosion and bottom scouring through high flow volumes, resulting in increased sedimentation and other habitat impacts.

The primary urban sources of sediment are construction sites and other pervious lands. Construction sites have high erosion rates due to the removal of vegetation and top soil. Typical erosion rates for construction sites are 35 to 45 tons per acre per year as compared to 1 to 10 tons per acre per year for cropland. Residential lawns and other green spaces contribute sediment in the same fashion as low-intensity pasture areas or other similar land uses.

Urban land use areas were separated into pervious and impervious fractions based on the estimated percent impervious surface of each urban land use category. Field observations and literature values were used to determine the effective percent imperviousness of urban land uses (Table 4.1).

Table 4.1 Percent imperviousness of urban land uses

Urban land uses	Percent impervious
High Intensity Residential	40%
Low Intensity Residential	20%

4.2 Assessment of Point Sources

Point sources can contribute sediment loads to surface waters through effluent discharges. These facilities are permitted through the Virginia Pollutant Discharge Elimination System (VPDES) program that is managed by VADEQ. VPDES individual permits are issued to facilities that must comply with permit conditions that include specific discharge limits and requirements. There are currently three individually permitted facilities in the Upper Clinch River watershed: Tazewell WWTP (VPDES #VA0026298), Greater Tazewell Reg WTP (VPDES #VA0053465), and Glenrae II Mobile Home Park STP (VPDES #VA0065676).

General permits are granted for smaller facilities that must comply with a standard set of permit conditions, depending on facility type. Currently, the Tazewell County Landfill (VPDES #VAR051267) (stormwater, general) and Bannies Wash Bays (VPDES #VAG750017) are the only facilities in the Upper Clinch River watershed that have been issued general permits. A list of all permitted facilities in the Upper Clinch River watershed is presented in Table 4.2.

Table 4.2 VPDES permitted facilities in the Upper Clinch River watershed

Stream	Facility Name	VPDES Permit No.	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L)	TSS Load (metric tons/year)
Mundy Branch, UT	Glenrae II Mobile Home Park STP	VA0065676	Municipal	0.4850	60	0.4021
Clinch River	Tazewell WWTP	VA0026298	Municipal	2.0000	30	82.9005
Clinch River	Greater Tazewell Area Reg WTP	VA0053465	Municipal	0.0250 (total flow)	60	2.6200
Clinch River, UT	Tazewell County Landfill*	VAR051267	Stormwater	0.4639	100**	7.7427
Mundy Branch, UT	Bannies Wash Bays	VAG750017	General	0.0010	30	0.0634

*Permitted load for this facility was calculated as the average annual modeled runoff times the area governed by the permit times a maximum TSS concentration of 100 mg/L. Flow was based on the average annual runoff from urban lands.
**No limit was specified in the permit; threshold value was used.

SECTION 5

WATERSHED MODELING

5.1 Overall Technical Approach

As discussed in Section 2.1, a reference watershed approach was used in this study to develop TMDLs for the Upper Clinch River. A watershed model was used to simulate the sediment loads from potential sources in impaired and reference watersheds. The watershed model used in this study was the Generalized Watershed Loading Functions (GWLF) model (Haith and Shoemaker 1987). GWLF modeling was accomplished using the BasinSim 1.0 watershed simulation program, which is a windows-based modeling system that facilitates the development of model input data and provides additional functionality (Dai et al. 2000). Numeric endpoints were based on the unit-area loading rates that were calculated for the reference watershed. A TMDL was then developed for the impaired stream segment based on these endpoints and the results from load allocation scenarios.

5.2 Watershed Model

TMDLs were developed using BasinSim 1.0 and the GWLF model. The GWLF model, which was originally developed by Cornell University (Haith and Shoemaker 1987, Haith et al. 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. GWLF is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values.

GWLF is an aggregate distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous with respect to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss/erosion (K), the length/slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff is applied to the calculated erosion to determine sediment yield for each source area. Point source discharges also can contribute to loads to the stream. Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker 1987) and GWLF User's Manual (Haith et al. 1992).

For execution, the model requires three separate input files containing transport, nutrient, and weather-related data. The transport file (TRANSPRT.DAT) defines the necessary parameters for each source area to be considered (e.g., area size, curve number) as well as global parameters (e.g., initial storage, sediment delivery ratio) that apply to all source areas. The nutrient file (NUTRIENT.DAT) specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations). The nutrient file is necessary for the model to run but is not used in any of the calculations. The weather file (WEATHER .DAT) contains daily average temperature and total precipitation values for each year simulated.

5.3 Model Setup

Watershed data needed to run the GWLF model in BasinSim 1.0 were generated using GIS spatial coverages, water quality monitoring and streamflow data, local weather data, literature values, and other information. Watershed boundaries for the Upper Clinch River and the Walker Creek watershed were delineated based on hydrologic and topographic data (USGS 7.5 minute digital topographic maps (24K DRG - Digital Raster Graphics)), and the location of VADEQ monitoring stations. The outlet of the Upper Clinch River watershed is the downstream limit of the impaired segment, which is also the mouth. The reference watershed outlet is located at the VADEQ biomonitoring station on Walker Creek. To equate target and reference watershed areas for TMDL development, the total area for the reference watershed was reduced to be equal to the area of the Upper Clinch River watershed, after hydrology calibration. To accomplish this, land use areas (in the reference watershed) were proportionally reduced based on the percent land use distribution.

Local rainfall and temperature data were used to simulate flow conditions in modeled watersheds. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations. The weather stations and data periods that correspond with the modeled watersheds are shown in Table 5.1. The periods of record selected for model calibration runs (April 1, 1991 through September 30, 2002 for the Upper Clinch River model and April 1, 1981 through May 31, 1999 for the reference model) were based on the availability of recent weather data and corresponding streamflow records.

Table 5.1 Weather stations used in GWLF model

Watershed	Weather Station	Data Type	Data Period
Upper Clinch River	Wytheville 1S (VA9031)	Daily Temperature, Daily Precipitation	4/1/1990 - 3/31/2003
Walker Creek	Wytheville 1S (VA9031)	Daily Temperature, Daily Precipitation	4/1/1990 - 3/31/2003

Daily streamflow data are needed to calibrate watershed hydrologic parameters in the GWLF model. A USGS gage station located on Clinch River at Cleveland, VA was used to calibrate the impaired watershed and a USGS gage on Walker Creek at Bane, VA was used to calibrate the reference watershed. Table 5.2 lists the USGS gaging stations along with the period of record used for the watersheds.

Table 5.2 USGS gaging stations used in GWLF model calibration

Modeled Watershed	USGS station number	USGS gage location	Data Period
Upper Clinch River	03524000	Clinch River at Cleveland, VA	4/1/1991 - 9/30/2002
Walker Creek	03173000	Walker Creek at Bane, VA	4/1/1981 - 5/31/1999

5.4 Explanation of Important Model Parameters

In the GWLF model, the nonpoint source load calculation is affected by terrain conditions, such as the amount of agricultural land, land slope, soil erodibility, farming practices used in the area, and by background concentrations of nutrients (nitrogen and phosphorus) in soil and groundwater. Various parameters are included in the model to account for these conditions and practices. Some of the more important parameters are summarized as follows:

Areal extent of different land use/cover categories: The MRLC land use coverage was used to calculate the area of each land use category in impaired and reference watersheds, respectively.

Curve number: This parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use/cover and hydrologic soil type and is calculated directly using digital land use and soils coverages. Soils data for both the impaired and reference watersheds were obtained from the State Soil Geographic

(STATSGO) database for Virginia, developed by NRCS.

K factor: This factor relates to inherent soil erodibility, and it affects the amount of soil erosion taking place on a given unit of land. The K factor and other Universal Soils Loss Equation (USLE) parameters were downloaded from the NRCS Natural Resources Inventory (NRI) database (1992). Average values for specific crops/land uses in the county were used (Tazewell County). The predominant crop grown in this watershed is corn; therefore, cropland values were based on data collected in corn crops.

LS factor: This factor signifies the steepness and length of slopes in an area and directly affects the amount of soil erosion.

C factor: This factor is related to the amount of vegetative cover in an area. In agricultural areas, this factor is largely controlled by the crops grown and the cultivation practices used. Values range from 0 to 1.0, with larger values indicating a higher potential for erosion.

P factor: This factor is directly related to the conservation practices used in agricultural areas. Values range from 0 to 1.0, with larger values indicating a lower potential for erosion.

Sediment delivery ratio: This parameter specifies the percentage of eroded sediment delivered to surface water and is empirically based on watershed size.

Unsaturated available water-holding capacity: This parameter relates to the amount of water that can be stored in the soil and affects runoff and infiltration.

Other less important factors that can affect sediment loads in a watershed also are included in the model. More detailed information about these parameters and those outlined above can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

5.5 Hydrology Calibration

Using the input files created in the BasinSim 1.0, GWLF predicted overall water balances in impaired and reference watersheds. As discussed in Section 5.3, the modeling period is determined based on the availability of weather and flow data that were collected during the same time period. For the impaired watershed (Upper Clinch River) weather data obtained from the NCDC meteorological station located at Wytheville were used to model the watersheds. However, the calibration period was governed by the availability of the USGS gaging data. The Upper Clinch River watershed was calibrated for a period of 11.5 years from 4/1991 to 9/2002 using the streamflow gage data from the nearby USGS gage 03524000 on the Clinch River at Cleveland, VA, and the Walker Creek watershed was calibrated for a period of 18 years from 4/1981 to 6/1999 using the streamflow gage data from the nearby USGS gage 03173000 on Walker Creek at Bane, VA. Although the streamflow gages are in close proximity to the reference and the impaired streams, the gages did not coincide with the pour points of the watersheds. Hence, the streamflow measurements were normalized by area to facilitate calibration. Calibration statistics are presented in Table 5.3. These results indicate a good correlation between simulated and observed results for these watersheds. A total flow volume error percentage of approximately 13 percent was achieved in calibration of the model for the impaired watershed, and less than four percent for the reference watershed. In general the seasonal trends and peaks are captured reasonably well for the 11 and 18 year periods in the impaired and reference watersheds, respectively. Hydrology calibration results and the modeled time period for the reference and the impaired watersheds are given in Figures 5.1 and 5.2. Differences between observed and modeled flows in these watersheds are likely due to inherent errors in flow estimation procedures based on normalization for watershed size and possibly due to the proximity of the location of the weather station to the watersheds and the flow gage.

Table 5.3 GWLF flow calibration statistics

Modeled Watershed	Simulation Period	R2 (Correlation) Value	Total Volume % Error
Upper Clinch River	4/1/1991 - 9/30/2002	0.3652	13%
Walker Creek	4/1/1981 - 5/31/1999	0.4383	3.4%

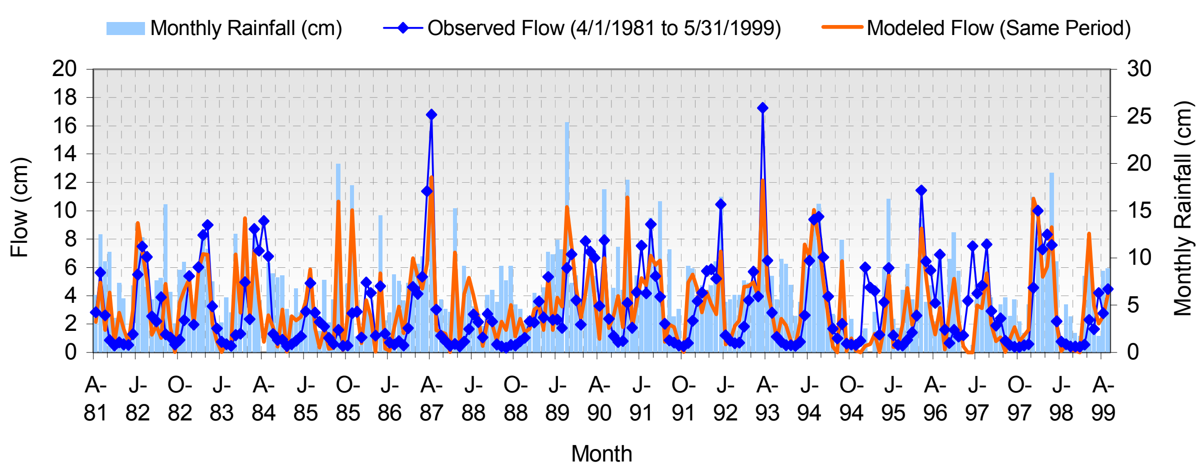

Figure 5.1 Walker Creek hydrology calibration using USGS gage 03173000

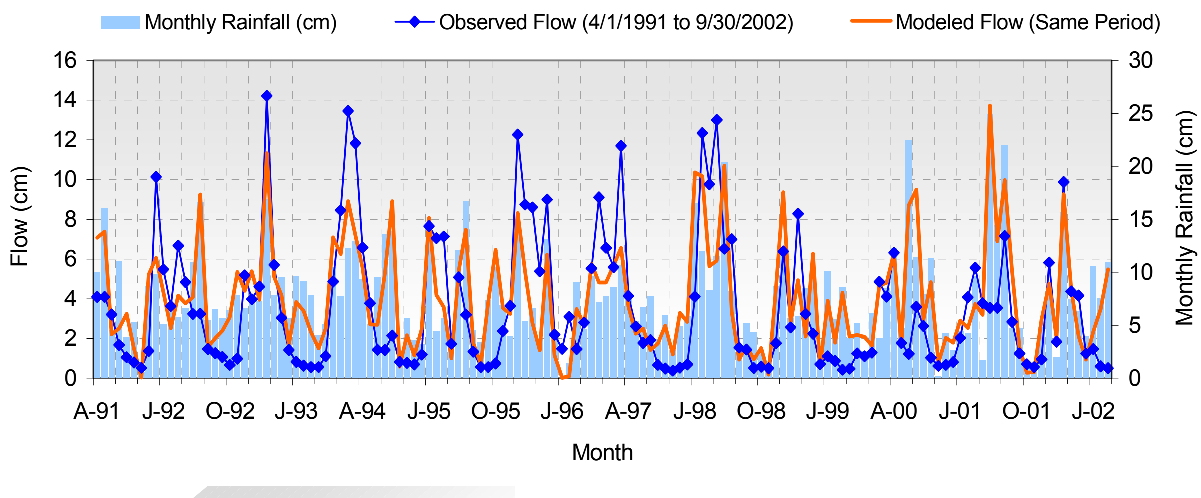

Figure 5.2 Upper Clinch River hydrology calibration using USGS gage 03524000

SECTION 6

TMDL METHODOLOGY

6.1 TMDL Calculation

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. To establish baseline (reference watershed) loadings for sediment the GWLF model for the Walker Creek watershed was used. For TMDL calculation both the calibrated reference and impaired watershed were run for an eight-year period from 4/1/1991 to 3/31/1999. This was done to standardize the modeling period. Based on the weather and limited flow data it is assumed that this period sufficiently captures hydrologic and weather conditions. In addition, the total area for the reference watershed was reduced to be equal to the target watershed, as discussed in Section 5.3. This was necessary because watershed size influences sediment delivery to the stream and other model variables.

The seven-year annual average for pollutants of concern were determined for each land use/source category in the reference and the impaired watershed. The first few months of the model run were excluded from the pollutant load summaries because the GWLF model takes a few months in the first year to stabilize. Model output is only presented for the years following the initialization year, although the model was run for an eight-year time period. The existing average annual sediment loads for the Upper Clinch River are presented in Table 6.1.

Table 6.1 Existing sediment loading in the Upper Clinch River watershed

Source Category	Sediment Load (pounds per year)	Sediment % of Total
Forest	223,395	1.5%
Water	0	0.0%
Pasture/Hay	11,669,506	78.4%
Cropland	2,174,804	14.6%
Barren/Transitional/Quarries	134,189	0.9%
Urban (includes pervious & impervious)	483,534	3.2%
Groundwater	0	0.0%
Point Sources	206,636	1.4%
Total Existing Load	14,892,064	100.0%

The TMDLs established for the Upper Clinch River consist of a point source waste load allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDL for the Upper Clinch River was based on the total load calculated for the Walker Creek watershed (area adjusted to the appropriate watershed size). Loads for urban areas have been lumped together (pervious and impervious). The sediment loadings from the impervious urban areas were estimated by multiplying literature values of the unit area loading rates (840 kg/ha/yr) times the impervious urban area in the watershed.

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. An explicit MOS of ten percent was used in TMDL calculations to provide an additional level of protection for designated uses.

The TMDL for the Upper Clinch River was calculated by adding reference watershed loads for sediment together with point source loads to give the TMDL value (Table 6.2).

Table 6.2 TMDL for Upper Clinch River

TMDL (lbs/yr)	LA (lbs/yr)	WLA (lbs/yr)	MOS (lbs/yr)	Overall % Reduction
7,580,309	6,614,615	Total = 206,636 *Glenrae Mobile Home = 886* *Tazewell WWTP = 182,764* *Greater Tazewell Area Reg WTP = 5,776* *Tazewell County Landfill = 17,070* *Bannies Wash Bays = 140*	759,058	54.2%

6.2 Waste Load Allocation

A waste load allocation was assigned to the point source facilities in the watershed. Point sources were represented by their current permit conditions and no reductions were required from the point sources in the TMDLs. Current permit requirements are expected to result in attainment of WLAs as required by the TMDL. Note that the sediment WLA values presented in the previous table represent the sum of all point source WLAs in each watershed, minus in-stream transport loss (as described on page 6-1).

6.3 Load Allocation

Load or waste load allocations were assigned to each source category in the watersheds. Several allocation scenarios were developed for the Upper Clinch River watershed to examine the outcome of various load reduction combinations. The recommended scenario for the Upper Clinch River

(Table 6.3) is based on maintaining the existing percent load contribution from each source category. Two additional scenarios are presented for comparison purposes (Table 6.4). Load reductions from agricultural sources are minimized in the first alternative and reductions from urban lands are minimized in the second alternative. The recommended scenario balances the reductions from agricultural and urban sources by maintaining existing watershed loading characteristics. In each scenario, loadings from certain source categories were allocated according to their existing loads. For instance, sediment loads from forest lands represent the natural condition that would be expected to exist; therefore, the loading from forest lands was not reduced. Also, sediment loads from point sources were not reduced because these facilities are currently meeting their pollutant discharge limits and other permit requirements and because these loads were insignificant as compared with other sources. Current permit requirements are expected to result in attainment of the WLAs as required by the TMDL. Point source contributions, even in terms of maximum flow, are minimal, therefore, no reasonable potential exists for these facilities to have a negative impact on water quality and there is no reason to modify the existing permits.

Note that streambank erosion loads were not calculated separately due to the lack of available data. Agricultural production has caused streambank erosion along several stream sections in these watersheds; therefore, TMDL implementation should include streambank stabilization measures which can lead to a significant reduction in sediment loads in these watersheds.

Table 6.3 Recommended sediment allocations for Upper Clinch River

Source Category	Sediment Load Allocation (lbs/yr)	Sediment % Reduction
Forest	223,395	0%
Water	0	0%
Pasture/Hay	5,134,583	56%
Cropland	978,662	55%
Barren/Transitional/Quarries	60,385	55%
Urban (includes pervious & impervious)	217,590	55%
Groundwater	0	0%
Point Sources (WLA)	Total = 206,636 *Glenrae Mobile Home = 886* *Tazewell WWTP = 182,764* *Greater Tazewell Area Reg WTP = 5,776* *Tazewell County Landfill = 17,070* *Bannies Wash Bays = 140*	0%
TMDL Load (minus MOS)	6,821,251	54%

Table 6.4 Alternative sediment allocations for Upper Clinch River

Source Category	Minimize Agricultural Reductions	Minimize Urban Reductions
Forest	0.0%	0.0%
Water	0.0%	0.0%
Pasture/Hay	54.0%	59.0%
Cropland	54.0%	54.0%
Barren/Transitional/Quarries	90.0%	0.0%
Urban (includes pervious & impervious)	95.0%	0.0%
Groundwater	0.0%	0.0%
Point Sources (WLA)	0.0%	0.0%

6.4 Consideration of Critical Conditions

The GWLF model is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is usually a significant lag time between the introduction of sediment to a waterbody and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the waterbody.

6.5 Consideration of Seasonal Variations

The continuous-simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The combination of these model features accounts for seasonal variability.

SECTION 7

REASONABLE ASSURANCE AND IMPLEMENTATION

7.1 TMDL Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairments on the Upper Clinch River. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the recent "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the VADEQ and VADCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

7.2 Staged Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement. The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;
2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;

3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;
4. It helps ensure that the most cost effective practices are implemented first; and
5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

7.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to ongoing water quality improvement efforts aimed at restoring water quality in the Chesapeake Bay. The BMPs required for the implementation of the sediment allocations in the watersheds contribute directly to the sediment reduction goals set as part of the Chesapeake Bay restoration effort. A new tributary strategy is currently being developed for the Shenandoah-Potomac River Basin to address the nutrient and sediment reductions required to restore the health of the Chesapeake Bay. Up-to-date information on tributary strategy development can be found at http://www.snr.state.va.us/Initiatives/TributaryStrategies/shenandoah.cfm.

7.4 Reasonable Assurance for Implementation

7.4.1 Follow-Up Monitoring

VADEQ will continue monitoring 6BCLN346.80 in accordance with its biological monitoring program. VADEQ will continue to use data from this monitoring station and related ambient monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

7.4.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of VADEQ, VADCR, and other cooperating agencies.

Once developed, VADEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and VADEQ, VADEQ also submitted a draft Continuous Planning Process to EPA in which VADEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

7.4.3 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. Section 319 funding is a major source of funds for Virginia's Nonpoint Source Management Program. Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

SECTION 8

PUBLIC PARTICIPATION

A stakeholder and TMDL study kickoff meeting was held on April 10, 2003. A site visit to the Upper Clinch River was also conducted on this date. Important information regarding likely stressors and sources was discussed with state environmental personnel and local stakeholders.

The first public meeting on the development of TMDLs for the Upper Clinch River was held on June 23, 2003 from 7-10 p.m. at Nuckolls Hall at the Tazewell County Fairgrounds in Tazewell, Virginia. Copies of the presentation materials were made available for public distribution at the meeting.

The second public meeting on the TMDL development for the Upper Clinch River was held on February 10, 2004 from 7-10 p.m. at the Fuller-Perry Exhibition Hall at the Tazewell County Fairgrounds in Tazewell, Virginia. Copies of the Draft TMDL report and presentation materials were made available for public distribution at the meeting.

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